Chemicals From Coal

CHEMISTRY

UNIVERSITY
JUL 1945

TO THE AMERICAN PEOPLE:

Your sons, husbands and brothers who are standing today upon the battlefronts are fighting for more than victory in war. They are fighting for a new world of freedom and peace.

We, upon whom has been placed the responsibility of leading the American forces, appeal to you with all possible earnestness to invest in War Bonds to the fullest extent of your capacity.

Give us not only the needed implements of war, but the assurance and backing of a united people so necessary to hasten the victory and speed the return of your fighting men.

William D. Leahy
E. J. King
Dwight D. Eisenhower
C. W. Nimitz

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25¢

★ A SCIENCE SERVICE PUBLICATION ★

No Magic in Chemistry

➤ POLYMERIZATION is a bigger word than abracadabra. The stuff chemists can conjure out of air, coal and salt is certainly reminiscent of the wishing ring. The catalyst whose mere presence causes new materials to appear seems more than a little like a magic spell.

But advances in science do not come through catching the Devil by the tail and forcing him to reveal a magic word. They come through serious hard work, with the foundation of four or eight or eleven years of study, in high school and college and graduate school. The earlier the kids get started in the methods of science the better.

Civilization is built on science and is dependent on it for continuation. We are already in debt to the future for thousands of young lives diverted from the laboratory, where they might have been using their talents to shorten the war and build constructive living conditions for peace.

Man has learned slowly and painfully how to exploit his surroundings. He knows how to consume the deposits of coal, oil and metals that he happens to find in the earth. He can use up trees faster than he can replace them. He can turn fertile river valleys into barren deserts. So far he has been lucky. He has found new resources to exploit as old ones have vanished.

He has just begun, fumblingly, to try to live on his income. He remembers, when he is hungry, to fertilize his fields. He is very proud of his use of by-products to manage known resources more efficiently. He is beginning to rely on synthetics from annual crops to replace materials from the harvests of millenia before his time. Maybe, if he can learn enough soon enough he can begin to outdistance doom. This is the task of science.

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▶ TOWERS *where coke-oven gas is washed and cooled to separate ammonia before the benzol products are recovered.*

Chemicals From Coal

by M. LELYN BRANIN

▶ COAL IS our greatest source of energy in this country. But it is more than that. It is the raw material for a myriad of everyday products such as dyes, plastics, perfumes, explosives, drugs, and other commodities. The value of the finished materials greatly exceeds that of the original coal.

The first step in this transformation is the conversion of bituminous coal into coke and byproduct crudes, an operation which alone last year consumed about 90,000,000 tons of coal or approximately one out of every 6½ tons mined during the year. Every minute of the day and night 3½ carloads of coal are being dumped into byproduct ovens in the U. S.

The earliest byproduct ovens in this country were established to furnish ammonia. Soon afterward the rapidly growing steel industry needed coke for

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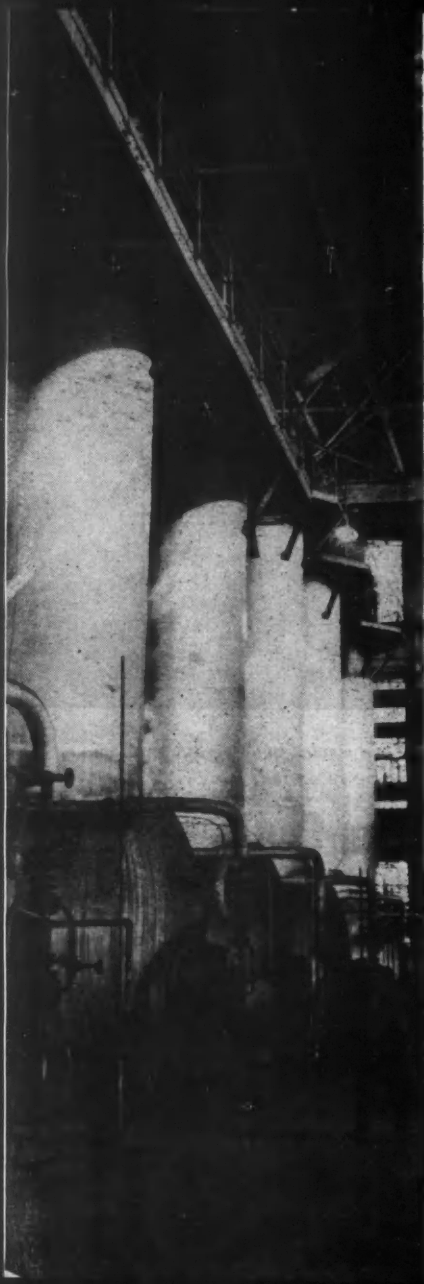


the production of pig iron and steel. Supplying metallurgical coke to the steel industry has continued uninterruptedly.

During the past 30 years coke production has increased almost 500% from 11,200,000 tons in 1914 to 66,600,000 tons in 1944.

At the time of the First World War the United States was almost entirely dependent upon German coal tar crudes and intermediates for our chemical industry. Serious shortages of phenol and toluene for explosives quickly developed, many medicinals were of dubious quality, and dyes were so unstable that scarcely any vestige of color remained after a few launderings. Prices of many chemicals went sky high.

This, however, has changed during the past 25 years as a result of the simultaneous growth of the coal processing and the synthetic organic chemicals industries, the former supplying the chemical crudes and the latter transforming them into thousands of intermediates and finished products. Not only have critical shortages of key chemicals failed to materialize in this war, but in many cases the amount available has been adequate not only to augment the supply of our Allies but also to meet in a limited way our own civilian needs. The age of a German-centered chemical world has definitely passed.

➤ BENZOL STILLS *separate the oils from coal distillation into fractions boiling at different temperatures. From each of these fractions many different chemicals are extracted.*

Carbonization of Coal

The modern byproduct plant in this country consists of a battery of ovens, each of which is surrounded on the sides with vertical flues in which hot gases are burned in order to maintain the walls of the oven at the required high temperature. Bituminous coal is charged into the oven through openings in the top, after which the oven is sealed tight and heat is applied. As the temperature in the oven rises, exhaust gases and vapors are given off and these in turn are carried by large conveyor pipes to the recovery units.

The gases and vapors are cooled upon leaving the oven by a water spray, with the result that a gaseous and a liquid fraction are formed. From these are separated ammonia, light oil, phenol, pyridine, naphthalene, and coal tar. Other substances, such as cyanogen and sulfur dioxide, may be recovered for further utilization depending upon the facilities of the plant. Following removal of these substances, coal gas is left.

Coal gas may be employed in heating the ovens, conveyed to nearby steel plants for fuel purposes, or piped into city gas mains to serve as ordinary domestic and industrial fuel. Over 1,011,000,000 thousands of cubic feet

▶ LIFE, *not death to plants, comes from this Sahara of ammonium sulfate. Ammonia from coke-oven gas is combined directly with sulfuric acid and sold for fertilizer.*

➤ CRUDE PHTHALIC ANHYDRIDE *crystals are raked out of a condensing bin. Anthraquinone dyes, insect repellents, plasticizers for smokeless powder and synthetic rubber, and the alkyd type resins used in paints for military equipment come from phthalic anhydride.*

of gas were thus produced last year.

After removal of the byproducts, approximately 1,400 pounds of coke remain for each ton of coal charged into the ovens. While the yield of byproducts may be varied to some extent depending upon the temperature at which the coal is carbonized, a ton of coal ordinarily yields about 10,000 cubic feet of gas, 3 gallons of light oil, 9 gallons of coal tar, and from 22 to 27 pounds of ammonium sulfate—the

form in which the ammonia usually is recovered—made by passing ammonia gas into a bath of dilute sulfuric acid.

About half of the coal tar is sold to tar processors for distillation and half is used as a fuel, especially in open hearth furnaces where it is particularly valuable because of its low sulfur content and its high radiant energy when burned. Many steel plants "top" the tar before using it as a fuel, that is, they remove the lower boiling fractions containing the valuable light oil, tar acids, and naphthalene and send them to tar refiners for further processing.

Most Important Crudes

Ammonia, benzene, toluene, phenol, and naphthalene are the most important byproducts from an industrial standpoint.

The ammonia is largely converted into ammonium sulfate for use as a fertilizer, over 1,600,000,000 pounds having been produced in 1944.

Benzene and toluene, which comprise about 88% by volume of the light oil fraction, top the priority list of war chemicals.

Benzene during the past three years has enjoyed a four-way squeeze. Vast quantities are needed for high-test aviation fuel—it has long been used to boost the anti-knock value of motor fuels—and tremendous quantities are required for conversion into phenol for war plastics and high explosives. It is also a critical material in the synthetic rubber program since by way of ethylbenzene it is converted into styrene, the copolymer in the manufacture of Buna S rubber. And benzene is the starting material in the manufacture of aniline and other dye-forming substances and hence is in constant demand by the dyestuffs industry. In addition to these uses, benzene is an important basic chemical in the manufacture of rubber accelerators, medicinals, photographic developers, paint and enamel resins, and other substances.

The principal use of toluene in wartimes, of course, is in the manufacture of trinitrotoluene (T.N.T.) which is accomplished by nitrating it with a mixture of nitric and sulfuric acids. It is also widely used as a starting material in the manufacture of dyes, medicinals, perfumes, flavoring materials, and food preservatives.

Phenol, although obtained directly from coal tar, is not produced in sufficient quantities to meet present day demands, with the result that large amounts are being made from benzene. Especially useful in this respect is the relatively new vapor phase catalytic method of synthesizing it direct from benzene. Principal uses are in the manufacture of plastics and explosives. It is also one of the most widely used disinfectants.

Last but by no means least of these five important coal derivatives is naphthalene, one of the most versatile of all from the standpoint of diversified chemical usage. Familiar to all as moth flakes and moth balls, naphthalene at present is being transformed on a vast scale into weather-resistant paints and enamels, insect repellants, dyes and dyestuffs, and rubber chemicals. Its

production last year amounted to approximately 388,000,000 pounds, as compared with 72,500,000 pounds in 1940. This five-fold increase in production during the past five years is a measure of its industrial importance.

Explosives

The explosives industry is very largely dependent upon the byproduct coke industry for its chemical raw materials. Practically the sole source in normal times of toluene, the starting material in the manufacture of T.N.T., is bituminous coal. Approximately ½ gallon of toluene is obtained from every ton of coal carbonized in a byproduct oven. This amount however is inadequate to meet the tremendously increased demands in wartime, with the result that the supply has to be supplemented from other sources.

Picric acid or trinitrophenol, another important high explosive, likewise comes from coal by way of phenol. Sulfonation followed by nitration of phenol yields the finished product, although another method utilizes benzene as the starting material. Perhaps even more important is the ammonium salt of the

➤ SYNTHETIC RUBBER *comes from coke and lime, which combine in an electric furnace to form acetylene. Its polymer, monovinyl acetylene, combines with chlorine to form chloroprene. It again polymerizes to neoprene, which the man is stripping off the roller.*

acid, ammonium picrate, which is especially useful for armor-piercing shells. Other explosives utilizing coal as a source of raw materials are amatol, tetryl, ammonium nitrate, and nitrated hexamethylenetetramine.

The entire ammonia industry, so essential for the manufacture of all explosives, is based upon coal. In addition to the millions of cubic feet recovered each year at the byproduct plants, vast quantities of ammonia are produced from coke, air, and water by the well-known high-pressure direct synthesis process. The ammonia in turn is converted into nitric acid, the principal nitrating agent in the manufacture of explosives.

Dyes and Dyestuffs

Perkins' synthesis of the purple dye mauve from coal tar during his quest for a method of synthesizing quinine is classic. Ever since that eventful day in 1856, coal has been the raw material for hundreds of dye intermediates and thousands of finished dyestuffs. The association between coal tar and dyes has caused the designation "coal tar dye" to be applied rather indiscriminately to all synthetic organic dyes regardless of whether or not the starting chemical is obtained principally from coal tar. Years ago coal tar was the primary source, but according to modern processing methods even the aniline dyes today come basically from the light oil fraction, which in turn is recovered directly from the coal gas. The term coal tar dye is no longer accurate in a strict sense but rather is used in a general way to indicate coal origin. Approximately 95% of all dyes come from bituminous coal.

As recently as 1914 there was only one dyestuff manufacturer in the United States. During the past 30 years an immense synthetic organic chemicals industry has been developed in this country, no small part of which is the dye industry. At the present time there are over 100 dye manufacturers, of which at least ten are large corporations producing many types of dyes. The U. S. Tariff Commission currently lists over 500 dye intermediates, and some of the large dyestuff manufacturers have prepared on a laboratory scale over 20,000 different dyes, all of which can be duplicated if desired. Coal-derived dyes are used for every purpose from lipstick and cake frosting to clothing, house paints, typewriter ribbons, printing inks, and photographic color films. Sales of finished dyes in the U. S. in 1944 amounted to over $100,000,000.

Medicines

The best-known of coal-derived medicinals are the sulfa drugs or sulfonamides — sulfanilamide, sulfathiazole, sulfapyridine, sulfadiazine, and other lesser known members of the group—all of which utilize coal by-products as their starting materials. Sulfanilamide comes from benzene by way of aniline, acetanilide, and other intermediates. And pyridine, as is implied in the name of the finished product, is one of the starting materials

➤ THIS CAULDRON *of arsphenamine is typical of organic medicinals which are among the important products derived from coal-tar chemicals.*

in the manufacture of sulfapyridine.

Such common substances as aspirin, salol, phenacetin, acetanilide, and salicylic acid are other examples of coal chemicals as is the familiar sugar substitute, saccharin. The local anaesthetic, novocaine, is a coal derivative. So also are the antiseptic, hexylresorcinol, the germicide, mercurochrome, and the laxative and chemical indicator, phenolphthalin.

Phenol or carbolic acid and related cresols, both widely used disinfectants, are recovered directly from coal tar. From coal come the basic chemicals for the manufacture of the quinine substitutes that are playing such an important role in the war, especially in the malaria infested tropical areas of the South Pacific. Also of special interest at the present time is the B vitamin niacine, formerly called nicotinic acid. Other interesting types of medicinals which are dependent in part upon coal for their synthesis are the sleep-producing barbiturates, and the aromatic arsenicals, arsphenamine and neoarsphenamine.

Perfume Materials

In normal times the perfume industry gathers many of its raw materials from the four corners of the earth. When Europe was first plunged into war large stocks of natural perfume materials were on hand in this country, but with the cutting off of the natural sources of supply the industry was forced to depend largely on artificial or synthetic materials, many of which are produced from byproduct crudes. This increase in the market for synthetics stimulated perfume research, with the result that the quality of many synthetic materials has been so improved that they will compete favorably with, if not actually replace, many of the natural perfume materials after the war. Many of the most needed coal crudes, such as benzene, toluene, and phenol, have been available to the perfume industry only in very limited quantities due to their critical role in the war industries. In some cases substitute starting materials of a less essential nature have been found.

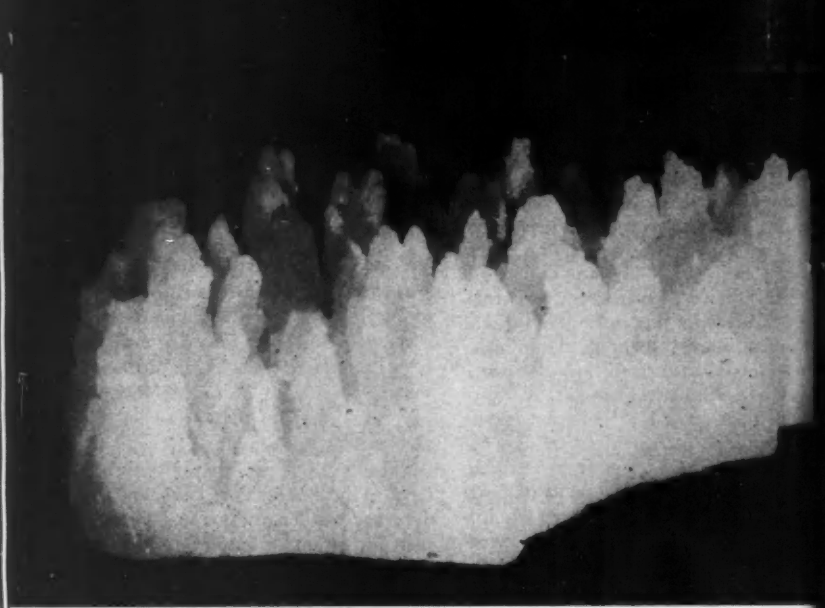
Perfumes are complex mixtures of many substances selected and blended. In addition the odor results from the blending of a number of components and most perfumes contain other classes of substances such as blenders, modifiers, fixatives, and diluents which modify the physical properties and seem to blend the many chemical smells used in the perfume.

From the coal-derived cresols the perfume chemist synthesizes the basic perfume material coumarin, widely employed as a sweetening agent and general background material, and an important fixative known as "artificial musk" because of its resemblance in properties to the natural musk of the male musk deer of Tibet. Toluene, in addition to serving as the starting material in the manufacture of explosives, dyes, and medicinals, is converted into such important perfume materials as benzaldehyde, benzyl acetate, benzyl chloride, and cinnamic acid. Phenol likewise, in addition to its use as a disinfectant and a basic chemical for plastics and explosives, is needed by the perfume manufacturer for conversion into synthetic wintergreen and the widely used rose-scented phenylethyl alcohol. These are but a few examples.

Perfume materials are not limited in their use to the substances called perfumes. On the contrary, they have an amazingly wide industrial range which includes their use in cosmetics, toilet goods, tobacco, foods, beverages, inks, medicines, and interior paints, as well as on leather goods, textiles, and stationery.

Plastics and Synthetic Resins

Ever since Dr. Leo Baekeland mixed phenol and formaldehyde in 1905 to obtain the first thermosetting resin, coal has been intimately associated with the development of the plastics industry and has continued to furnish the basic chemicals for most types of plastics and synthetic resins. It has been estimated that 85% of all plastics are made basically from coal. Among them are the phenolic, urea, polystyrene, vinyl, polyamide or nylon, methacrylate, alkyd, coumarone-indene, and melamine types. While coal is not the

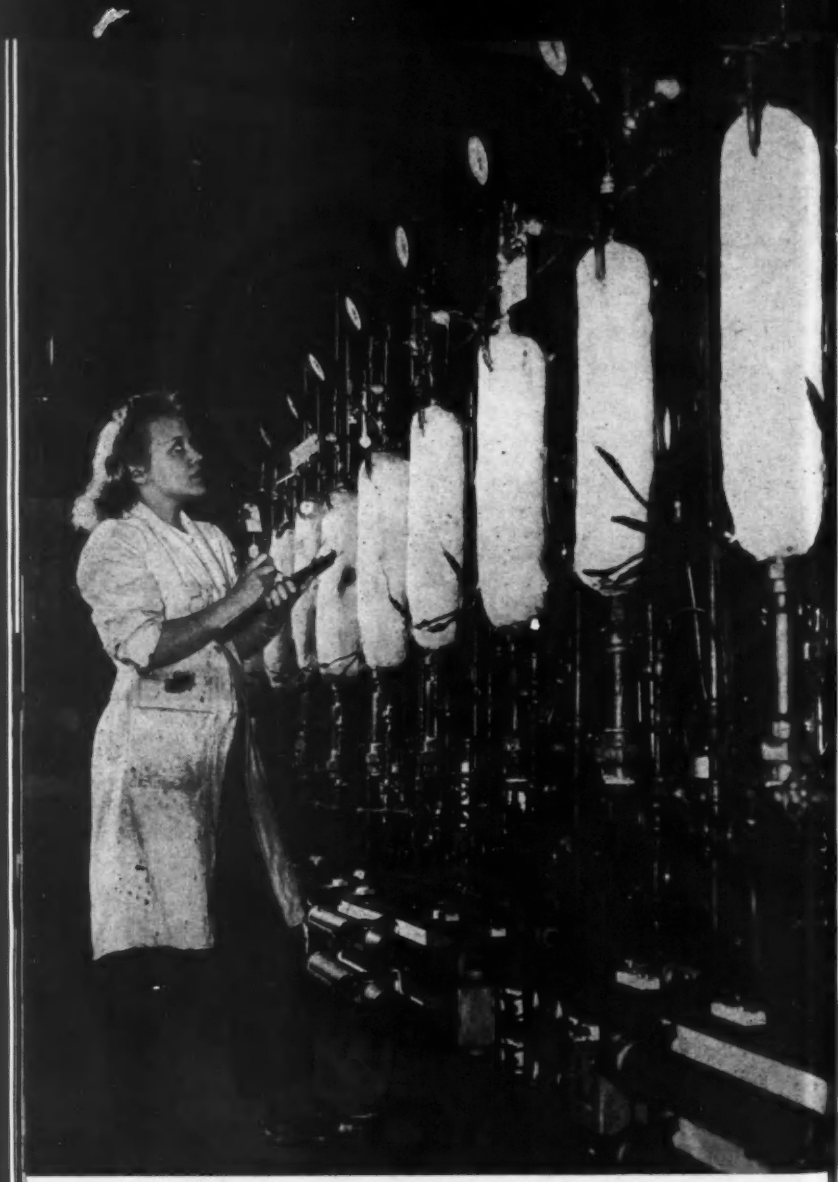


➤ FROM CRYSTALS *to plastics, the many types of coal-tar chemicals include coumarin, above, the solidified perfume of new-mown hay, and phenol-formaldehyde resin, below, flowing hot from the kettle.*

▶ THE MODERN *mechanical spider spins its chemical fiber, nylon.*

only source of raw materials for all of these resins, it is in most cases one of the principal sources. Even some of the cellulose plastics may in fact be partly coal-derived. The acetic acid or acetic anhydride used in the manufacture of cellulose acetate, for example, comes from coal by way of coke, calcium carbide, and acetylene. Approximately 0.8 pounds, calculated as the anhydride, are required for each pound of finished cellulose acetate produced. Likewise, the formaldehyde which is needed in the production of so many types of plastics, including the soy bean and casein types, is synthesized from coal via coke and water gas.

During the past few years synthetic resins have been used in a multitude of commodities from false teeth and artificial eyes to jungle hammocks, machine gears, military paints, and Navy life rafts. While extravagant claims have been made for plastics in some cases and disappointing results have been obtained due to choice of the wrong material for a particular purpose, they are sure to have important uses in the future. Their thermosetting or thermolabile character, noncorrosiveness, transparency or opacity, range of coloration, and ease of fabrication open wider opportunities for them in the future.



➤ TESTS *to determine which catalysts are most efficient in producing synthetic motor fuel are being run at the U. S. Bureau of Mines experimental laboratory in Pittsburgh.*

These synthetic resin materials are now used on an unprecedented scale in the manufacture of textile fibers and textile coating materials; in wind, water, and acid resistant paints; in printing and writing inks; in the plastic-bonded plywood used in making Mosquito bombers and small Navy craft; in fire and water resistant finishes for wood; and in numerous other ways. Present applications are largely military but in the near future they will be extended to civilian goods.

Synthetic Motor Fuel

A substantial portion of Germany's gasoline and Diesel fuel for war was produced synthetically from coal according to the Bergius hydrogenation and the Fischer-Tropsch water gas processes. Estimates placed Germany's productive capacity in 1942 for the Bergius process alone at 4,000,000 tons of motor fuel yearly. During the past several years Japan is reported to have been rapidly expanding facilities for producing synthetic motor fuel from coal. England also has supplemented its war supply of motor fuel with coal-derived gasoline from the Imperial Chemical Industries plant at Billingham, although apparently on a much smaller scale than in Germany.

During the past several years there has been interest in this country in the possibility of utilizing some of our domestic coals for the production of synthetic motor fuels, in view of the uncertainty of our petroleum reserves, and the large size of our known coal reserves, over 3,000,000,000,000 tons. Much of the research for such a project has already been done by the U. S. Bureau of Mines at its experimental laboratory in Pittsburgh, where both the Bergius and the Fischer-Tropsch methods have been investigated on a laboratory scale. Yields from various types of domestic coals and effects of certain catalysts, have been investigated. As a result of the $30,000,000 recently appropriated by Congress to erect a large research center near Pittsburgh with pilot plant facilities and to implement the program for a five-year period, considerable progress should be made within the next few years.

The United States contains approximately 51% of the total estimated coal reserves of the world. Our coal reserves constitute about 99% of the total energy that is derivable from all of the proved reserves of mineral fuels in the nation. This is the fundation upon which we are building. Upon it will rest to an ever-increasing degree the future industrial progress of the nation.

The photograph of coke on the back cover is by courtesy of The Koppers Co., plant pictures on pages 1, 2 and 3 by courtesy of U. S. Steel Corp., the chemicals phthalic anhydride, neoprene, coumarin and nylon by courtesy of Du Pont Co., organic medicinals by Merck & Co., phenol-formaldehyde resin by Durez Plastics & Chemicals, Inc., and the battery of tests for catalysts by Hamilton Wright.

On the Back Cover

▶ INCANDESCENT COKE *is pushed out of the by-product oven where fabulous chemicals have been removed from coal. Not only are these rich by-products valuable in themselves, but their removal actually makes coke a better fuel.*

Three High School Boys Manufacture and Sell Rare Chemicals

The Chemical Business

by EDWARD M. KOSOWER

Winner of the Boys' $2,400 Westinghouse Science Scholarship in the Fourth Science Talent Search*

▶ LATE last year, at emergency board meetings, the directors of du Pont, Union Carbide, and Allied Chemical discussed their prospects for the coming year. Gloom was the keynote of these worried gatherings, for lo! a competitor had arisen on their business horizons in New York. But wait! Why should the giants of the American chemical industry shudder and tremble so? The cause, as the story goes:

The roots of the matter reach back into March 1944. At that time, Lester Friedman, now 16½ and an upper freshman at Purdue, and I decided to found a chemical company dedicated to the manufacture of rare organic chemicals. I *do* mean dedicated, for as it turned out later, our numerical profits somehow refused to vacate the realm of imaginary numbers.

At first, we had considered the manufacture of amino acids, but after our advertisement had appeared in the Chemical & Engineering News, we rapidly changed our minds. Not that we didn't receive any inquiries. Quite the contrary. The veritable storm of requests for prices reached such heights that for almost a month, all that we did was reply to letters and type out price lists, but with no orders resulting! It seems that it would have been necessary to count on a negative margin of profit *before* we could count on an order for amino acids. And after all, in any business, the volume of mail must bear some relation of proportionality to the volume of income—and a zero does not work out well in a proportion. Therefore, we looked for some means of changing that zero to something tangible—whether profit or loss.

As it was my habit to peruse the current issues of the Chemical and Engineering News for the latest developments in chemistry, it was not long before the "Who Makes It?" list of the National Registry of Rare Chemicals, Armour Research Foundation in Chicago, Ill., attracted my attention sufficiently for me to become interested in its contents. The Registry acts as a clearinghouse for those who want to obtain, for research purposes, rare chemicals ordinarily found in research laboratories only. If you can supply any of the chemicals listed, you communicate with them and they notify the interested parties who then write to you directly. I discussed this with Lester and we decided to inform them that we could prepare certain compounds. There is no charge for the service, luckily for us!

In the due course of events, we received orders for several of these chemicals. We then proceeded to the

* See essay published in CHEMISTRY, April 1945, p. 57.

task of filling them . . . sad to say, we were greatly lacking in some of the requisite technique, knowledge, and experience. This was acquired during the passage of time as we worked in the lab and filled the orders.

But I am getting ahead of the story. The preparations which we attempted (and sometimes accomplished) were, of course, of an advanced nature and rarely performed outside of the walls of a research laboratory. In light of the aforementioned considerations, it was not surprising that the first order took three long months to fill—partially! In that time, we managed to prepare little more than half of the required quantity. We were beset by all manner of difficulties: financial, accidents, bad luck—and more bad luck. However, we staggered off from this encounter with large amounts of experience and small amounts of free capital. It certainly is not often that a gnat-sized manufacturer such as we are can keep the pachyderm General Electric Research Laboratories waiting for an order, but we (unfortunately) did it. I have conveyed our regrets for the incident to the chemist concerned, through a colleague of his whom I met at a New York Section, American Chemical Society meeting recently. Naturally, Westinghouse Electric and Manufacturing Company would have been accorded a much more considerate treatment—for obvious reasons. (Since these comments are being made in retrospect, some statements such as the latter might seem illogical from a strictly narrative viewpoint, but certain pertinent interjections into the subject matter cannot be resisted.)

During the summer of 1944, Andrew Streitwieser, who was awarded a $400 Westinghouse scholarship in the Fourth Annual Science Talent Search, was a member of the partnership. Andy is 17 and attends Columbia University. He resigned late in August because of other duties.

In that same summer, we successfully prepared and sold an obscure dyestuff to Johns Hopkins University, and a comparatively unknown organic chemical was purchased by the U. S. Army. We continued the practice of answering the Who Makes It? lists and through them obtained, in fact, all of our orders. Later that year, chemicals were sold to the Frigidaire Division of General Motors, to the Tennessee Eastman Corporation, and to the Union of South Africa government.

One might get the impression that our manufacturing activities consumed all of our energies. That was not the case, however, and much effort was devoted to research on a small scale. Several articles have been submitted to various publications and most are still under consideration. One was rejected on the basis that it reported negative results and that more work was being done in which these results could have been incorporated. The editor, himself, admitted the intrinsic value of the paper but advised us to submit a more complete paper at a later date.

While all the above feverish activity was maintained, we were both attending Stuyvesant High School in New York City. I can safely say that we were the most exhausted pair of students in the school.

Our company is still in business and, thus, its name or other too detailed

particulars cannot be revealed till another time. We want to have enough time to go into hiding when a group of indignant chemists descend upon New York, hunting for our scalps.

The company will probably be given up altogether after I start college. Its activities now are limited to completing business contracted or arranged for before this spring. Both of us are more interested in doing pure research, with as few strings attached as possible. It was an interesting experiment while it lasted, and, in view of the experience that we have both gained, I would consider it highly successful.

"Stink Bomb" For Sharks

➤ A NEW "stink bomb" for sharks chases them away from flyers downed in shark-infested waters. The new chemical weapon is obnoxious to the olfactory sense of sharks, keeping them away from flyers who use it. Dissolved in water, the repellent forms an inky black cloud that is almost odorless to humans, but to sharks it smells like decaying sharks' bodies, causing them to turn tail and swim off.

This effective deterrent to the toothed terrors of the deep is the product of several months' research which has resulted in the combining of a substance extracted from sharks' bodies and formed into a chemical salt, with a black dye that is so effective that it serves as a deterrent by itself. The dyes and chemical salt are pressed into a black cake, and packaged in a waterproof envelope which is attached to life vests. Downed flyers release the repellent into the water by ripping open the envelope tab.

Shark attacks on humans are rare, since man is not a shark's natural prey. The sight and smell of blood, however, doubles the danger to wounded flyers ditched in tropical waters. Comparatively rare though they are, shark attacks on humans are fatal in 80 per cent of the cases.

Developed primarily by the Air Technical Service Command to remove an incidental terror of war from the minds of American flyers, the history of the new repellent is a good illustration of the coöperation between the military, scientists, and industrial researchers. The ATSC engaged as consultant Dr. W. D. Burden, of the American Museum of Natural History, who had worked on a similar project at the Woods Hole (Mass.) Oceanographic Institute under the Office of Scientific Research and Development. In the search for an effective repellent many substances were tried, with little success, until a study of fisherman's lore revealed that sharks do not venture into waters polluted by decaying bodies of their own kind.

Later the Calco Chemical Company, in coöperation with the Naval Research Laboratory of the Bureau of Ships, developed the black dye.

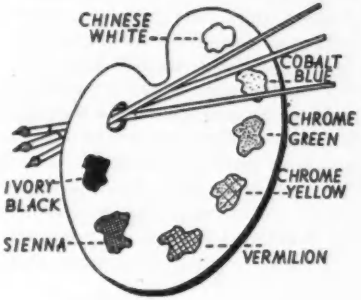
In open sea tests off the coast of South America and Florida, fish were thrown overboard from shrimp boats to attract sharks. The sharks struck in large numbers until the repellent was released into the sea. Then they dispersed and refused to venture back even after the repellent had become greatly diluted.

Convinced of the value of the shark chaser, the Army Air Forces is producing large quantities of shark-repellent packets.

Chem Quiz

The Painter's Palette

➤ THE PAINTER'S PALETTE holds many inorganic pigments. Can you give the formulas for those shown here? Page 56 completes the picture.



New Light Burns For Year

➤ A NEW BEACON light that will burn for a year without adjustment or refueling and that can be seen for about 12 miles has been developed by the Army Air Forces as a warning light for planes. It is to be placed on the peaks of high mountains and near other hazards located in isolated areas. It may be used as a civil airway marker after the war.

Known by the code name Type C-3, the new light is an acetylene-burning lantern designed for installation where electricity through power lines is not available. In operation a 400-candlepower beam is flashed for two-tenths of a second, 30 times a minute. Upper and lower lenses are fitted with red filters to throw the light in a complete 360-degree circle so that it can be observed by pilots from any direction.

The main burner has a three-cluster flame ignited by two constant pilot lights. Tiny holes in the base of the apparatus permit enough air to get in to keep the flame going. A baffle system prevents the light from being blown out by high winds.

The beacon is controlled by a sun-valve device which consists of four metal rods that are sensitive to light. These rods expand and contract when the outside light varies, and have a compensating device to take care of temperature changes. The expansion and contraction of the rods produces energy to operate the valve which governs the flow of fuel to the main burner.

Phenol Fights Termite

➤ WOOD-DESTROYING termites, that cause millions of dollars of damage to American homes each year, are repelled to a degree if the wood is impregnated with certain compounds of phenol, particularly with a copper-chlorine-phenol, Dr. George N. Wolcott, of the University of Puerto Rico, reports. The tests are still in progress and will be continued until methods for the more complete control of this pest have been perfected.

Phenol, familiar as carbolic acid, is one of the hydrocarbons obtained in the distillation of coal, or produced by treating benzene with sulfuric acid followed by a treatment with an alkali. Naphthalene for moth balls is made from it. Repeated tests with phenol alone indicate that its effect disappears rapidly, but in heavily chlorinated compounds it is more lasting, and in a copper compound, copper pentachlorophenate, more lasting still.

These tests were made to develop a repellent against the West Indian dry-wood termite known scientifically as Cryptotermes brevis. Other coal tar constituents may make more efficient termite repellents, but phenol has a low initial cost.

High Frequency Current in Tin-Plating

➤ GENERAL PROBLEMS of heating iron or steel strip by induction were analyzed at a meeting of the American Institute of Electrical Engineers by Robert M. Baker of the Westinghouse Research Laboratories, who referred to the relatively new process, in tin-plating electrolytically, of heating the iron strip by the use of high-frequency current to the melting point of tin, so that the tin as deposited is melted and flows into a uniform, tightly adhering layer, while the strip is moving at speeds up to 1,000 feet a minute or more.

This application, he says, requires the use of vacuum tube oscillator equipment (frequently about 200 kilocycles) because of the thinness of the strip to be heated. There are, however, many possible applications of induction heating to thicker iron or steel strip, he stated, which may be accomplished by rotating machines having an upper practical frequency of about 10,000 cycles per second. There is practically no limit to the thickness of strip which can be heated by induction, Mr. Baker finds, and strip widths up to four or five feet can be satisfactorily handled. He described simplified handling and heating equipment designed in his laboratories.

The discussion was limited to iron or steel strip which is ferro-magnetic, because such paramagnetic metals as copper, aluminum and brass cannot be satisfactorily heated by the usual process of induction heating, he said. Iron and steel lose their ferromagnetism between 700 and 800 degrees Centigrade and cannot be heated economically above this temperature by this method, he added.

Newer Resins Find Use in Textiles, Oil, Insulation, and Pharmaceuticals

Progress In Plastics

➤ NEW SYNTHETIC RESINS and plastics and new uses for old compounds are being made known day by day. Many of them are the result of war needs and will be useful in peace-time industry.

Silicone Insulating Enamel

➤ A SAND-BASED SILICONE, a new elastic electrical insulating enamel that will withstand continuous operation at 500 degrees Fahrenheit followed by sudden plunges into icy sea water, is the latest silicone material to be produced commercially and is to be used in the insulation of resistors that control the current fed into war radar, radio and other electronic essential equipment. It is produced by the Dow Corning Corporation.

The new silicone, which will be known as Silastic, is a rubbery, white salve-like material, that can be applied by dipping and cured at from 500 to 550 degrees Fahrenheit. In addition to passing tests for thermal shock endurance, it is waterproof, and can withstand immersion in boiling water as well as in ice water. Applied to glass cloth and tape, this coating produces a heat-resistant electrical wrapping material, and may be used in other applications to exclude moisture from electrical equipment.

Melamine Resin for Wool

➤ WOOL CLOTH may be shrunk, and its shrinkage controlled, by the use of a melamine resin developed by the American Cyanamid Company. The melamine resin is known as Lanaset, and the treated cloth cuts and drapes better, retains its original shape and can be laundered.

Lanaset stabilizes wool and wool blends without affecting the absorbency normally characteristic of wool. Other claims are that it reduces felting or matting of the wool upon laundering, and prevents pilling and fuzzing. It can be used also with blends of wool and rayon and in tropical worsteds for men's suits. It is now available for practical trials.

Acrylics for Oil

➤ A NEW ORGANIC chemical compound has been developed, for mixing with aviation oils in aircraft, which prevents dangerous thickening at extreme low temperatures and excessive thinning in tropical heat. Warplanes, using the mixture, can climb from desert heat to far-below-zero temperatures in the stratosphere with assurance that their mechanisms operated by hydraulic oils will continue to work, and recoil oils will function properly.

The new material, developed by the Rohm and Haas Company, is a water-white acrylic polymer, known as Acryloid HF. Acrylics are the foundation of the transparent plastic that is widely used in aviation for bomber noses, gun blisters and other plane enclosures.

Power transmission using hydraulic oils raises and lowers landing gear, operates power turrets, and controls rudders, elevators, ailerons, and even propeller pitch. The recoil oil is the shock-absorbing medium in guns of large and intermediate calibers. If the

recoil oil freezes, the plane might readily be torn apart by the kick of its own guns. If the hydraulic oils thicken too much, controls and power transmission mechanism will fail to operate. These dangerous conditions will not arise, it is claimed, when the new organic compound is properly mixed with the oil.

Rubberlike Plastics

➤ NEW RUBBERLIKE PLASTICS, with valuable wartime and postwar uses, will be made at Natrium, W. Va., in the near future in a new plant to be constructed by the Goodyear Tire and Rubber Company, which will have a capacity of 3,000,000 pounds a year. The new materials, developed by scientists of the company during the past two years, can be used to coat cloth and paper, package foods, drugs and tobacco, insulate electric wiring, and protect machinery during shipment to tropical regions.

These new synthetics, that can be used to relieve the critical shortage of natural rubber products, are vinyl chloride co-polymers. They are made by passing two gases, acetylene and hydrogen chloride, over catalysts in large tanks by a process very much like that used in making GR-S rubber from butadiene and styrene. GR-S rubber is a co-polymer made by joining the molecules of butadiene to the molecules of styrene. Each of the new co-polymers to be made in the new plant will consist of molecules of vinyl chloride joined with the molecules of some other substance to form the giant molecules of the plastic.

The new plastics can be vulcanized like rubber in the equipment ordinarily used by the rubber industry for that purpose. They resist the deteriorating effects of sunlight, and are also oil resistant and may be used for gaskets and washers, wherever an elastic, rubberlike substance resistant to oil is required.

An experimental tire has been made of the new material, but it is not expected at present that it will come into general use for tires.

Organic Salts Removed

➤ WATER IS NOW freed of undesirable mineral salts by filtration through specially-prepared synthetic resins and purified to a degree where it is nearly equivalent to distilled water in quality, and may be used in place of distilled water in many chemical processes, declared Dr. Robert J. Myers, of the Resinous Products and Chemical Company, Philadelphia, in a lecture at Western Reserve University. Sugar solutions, chemicals, and pharmaceutical products may be purified of inorganic salts by the same method, he said.

This modern method of producing water and chemical solutions free of inorganic salts consists in passing them through two beds of the special resins known as ion-exchange resins. The ion-exchange synthetic resins are of two kinds, he explained, a cation-exchanging type and an anion-exchanging type. The first will exchange sodium for calcium and magnesium ions, the latter two being the hardness-producing ions in water supplies, and the water is thereby softened. When the store of sodium ions in the resin is exhausted, the calcium and magnesium ions which have been captured by the resin during the softening process are flushed off by the use of strong salt

solutions and the rejuvenated resin is again ready for use.

"In a similar manner the same resins can be used as a storehouse of hydrogen ions," the speaker continued, "by treatment of the resin with a mineral acid, and the hardness-producing as well as the alkali-ions of water may be displaced by hydrogen ions."

Sodium bicarbonate alkalinity is converted to carbonic acid, and mineral salts, such as sodium sulfate, are converted to the free acids by the use of the hydrogen exchanger.

"The anion-exchanger resin is a similar gel-like substance which contains basic groups, such as amino, which bind mineral acids when placed into contact with acid solutions," Dr. Myers explained. "When the effluent from a hydrogen exchanger bed is passed through a bed of granulated, anion-exchanger resin, the free mineral acids generated in the first bed are bound by the second bed, and water free of all mineral salts emerges from the second bed."

Such "de-ionized" water is nearly equivalent to distilled water in quality and can be produced at a fraction of the cost, he added.

Water, de-ionized by this process, is being used in the manufacture of synthetic rubber, pharmaceuticals, plastics and in ceramics and metallurgy, he stated. Specific processes for the removal of dissolved salts from molasses, formaldehyde solutions, and sugar syrups, and other purposes, have been developed. Organic chemical synthesis, Dr. Myers said, has been combined with colloid chemistry in the development of the synthetic resin exchange adsorbents.

Polythene for Cables

➤ UNDERSEA electric cables may, in future days, be insulated with polythene plastic, it is predicted, because this material has excellent insulating qualities, is not attacked by seawater, resists penetration by moisture, and is unusually insoluble and inert to chemical reagents. It may be used also for protective coatings on machinery in or near salt water, to prevent corrosion.

This prediction was made by Dr. J. W. Shackleton of the plastics department of E. I. du Pont de Nemours and Company, at a meeting of the American Institute of Electrical Engineers.

"Polythene has very largely replaced all other materials in the insulation of military wires for high-frequency use," he said. "After the war it is expected that the use of polythene in electrical equipment will continue and expand, and that further varieties and modifications of it will be developed to meet specific needs."

Its good resistance to chemicals points to its utility in chemical equipment as a coating and gasketing material, the speaker continued. Its impermeability to moisture indicates a broad utility in containers and the packaging of foods. It is substantially unaffected at room temperature by concentrated hydrochloric, sulfuric, and even hydrofluoric acids, while nitric acid has no visible effect but does ultimately impair tensile strength and elongation.

Polythene, Dr. Shackleton explained, is the generic name applied by Imperial Chemical Industries, Ltd., who originally developed the material, and adopted by the Du Pont company to

designate the "giant molecule" forms of ethylene suitable for use in plastics.

Plastic Replicas

➤ THE SMOOTHNESS, or degree of finish, of metal parts can now be rapidly and satisfactorily determined by the use of nearly transparent plastic replicas, following methods developed by the National Bureau of Standards, and acceptable modes of specifying and designating surface finish will probably result. Metal smoothness specifications have been lacking in the past because no easy method of evaluating them had been worked out.

The new method, described by Harry K. Herschman of the Bureau staff in Mechanical Engineering, consists of applying a suitable solvent to the metal surface, then pressing on a strip of clear plastic film. The solvent softens the side of the film adjacent to the surface being examined and permits it to flow and conform under the pressure to the minute surface irregularities. The film dries in about a minute and can then be stripped off readily, giving a perfect facsimile of the surface.

After a replica is made, its degree of transparency depends upon its roughness; increased roughness results in decreased transparency. Also, the rougher the metal surface, the more pronounced are the variations in the regularity of the reproduced pattern. This fact led to the development of the apparatus for evaluating surface roughness, based upon the degree of variation of the geometric characteristics in a nearly transparent replica. In this apparatus a restricted beam of light passes through an oscillating test replica and to a photoelectric cell. The intensity of the light transmitted through the oscillating replica varies because of the unevenness of the surface of the pattern. Voltage readings of the current from the photoelectric cell may be calibrated in tems of the "peak-to-valley" values of the surface.

Resins Purify Penicillin

➤ A SIMPLE METHOD of purifying penicillin by means of synthetic resins is reported by Drs. E. Cruz-Coke, F. Gonzalez and W. Hulsen, of the University of Santiago, Chile.

Known as ionic exchange resins, these gel-like substances have already been used to free water and chemical solutions of inorganic salts. They are of two sorts, one which captures cations and the other anions. The Chilean scientists used specially prepared resins which absorbed proteins, amino acids and various other organic substances from biological materials.

By filtering penicillin first through the cationic resin, Ionac C, and then through the anionic resin, Ionac A, the Chilean scientists report obtaining a product which has all the penicillin activity of the original material but is free of toxicity for experimental animals and man. They believe this simple method will also be useful for purifying other active substances produced by molds and various biological agents. Present methods of purifying penicillin are time-consuming and costly.

The twelfth 82,500-kilowatt unit at Boulder Dam is now in use, bringing the total capacity of the world's largest power plant up to 1,034,800 kilowatts.

Chemical "Magic":

Floating Spheres of Oil

by JOSEPH H. KRAUS

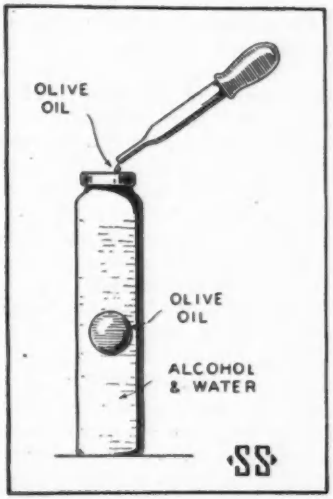
➤ BALLS OF SALAD OIL, as much as one inch in diameter, floating midway in a mixture of denatured alcohol and water, show that matter tends to take the form of a sphere. A body in the shape of a ball has the least possible surface.

All drizzle and minute raindrops form perfect spheres, but they move too fast for careful observation. Drops of water, falling on a hot plate, also shape themselves into spheres, each supported on a layer of steam. But again the movement usually is too rapid for more than a fleeting glimpse. Here is a good demonstration of the spherical shape.

Put some clean water, warmed to room temperature, into a tall bottle such as an olive bottle. Add a drop of ordinary salad oil, peanut oil, soybean, vegetable or olive oil. Gradually add some denatured alcohol, purchased from the hardware store or gas station. Shake well to mix thoroughly the water and alcohol.

A drop of oil will probably be floating on the surface. As more alcohol is added the drop of oil, becoming thicker, will sink. Carefully pour off half of the liquid into a clean glass. Now gradually add water to the bottle until the oil begins to float again.

Slowly pour in the alcohol and water mixture which you have saved. Do not mix. The oil will appear in the form of a ball floating midway in the liquid column.



Continue to add more salad oil. If the drops are small and do not run together, you will see that the smaller ones will remain nearer the top while the larger ones sink farther in the liquid.

Make Ball Larger

Poke an ordinary broom straw into one of the oil drops and spin it around. A number of small drops will join to form a much larger drop, sometimes even one inch in diameter. Such a large drop is difficult to break.

If you look through the drop at some object within focus at the far side of the glass you will find that the sphere of oil forms a crude magnifying lens.

If there are any air bubbles in the

water and alcohol mixture, some of these bubbles will attach themselves to the spheres of oil. Smaller ones will be carried to the surface of the liquid. Here the air bubbles will burst and the oil drops sink again to the mid-point. This action will continue for quite a while.

Textiles, Food, Electronics at M. I. T.

➤ TEXTILE RESEARCH, food technology and electronics are stepped to the front in the new program at the Massachusetts Institute of Technology. There have recently been established intensive and extensive courses of study and investigation in these three subjects, based on developments of the past, including the great forward strides under war impetus, the present needs of the armed services and civilians, and future world-wide production and needs. New laboratories and equipment will be available for the work.

The textile investigations will have the use of a new laboratory known as the Samuel Slater Memorial laboratory, named in honor of the man who, in 1790, built the first cotton spinning machinery and started the first cotton mill in the country. It will pioneer in the application of the most advanced scientific knowledge to research on fibers, yarns, and fabrics.

In food technology a far-reaching program to study postwar problems of world food production will be undertaken. It will include the improvement of products and methods for retaining natural flavors and nutritive elements in processed foods, and a study of packaging food products to provide better protection against the ravages of time and climatic conditions. It will make use of the developments of new food products in the past few years, and the accelerated progress in food technology due to the needs of armed services in many different parts of the world.

A new laboratory, bearing the name of Samuel Cate Prescott, will be used by the food technology division. It will be fully provided with food processing equipment and other facilities to carry out its program. The course will cover five years, during which men will spend considerable time in some of the country's great food manufacturing plants and in the research laboratories maintained at these plants.

In the new professional course in electronics, in which their application to television and highly developed production methods will be emphasized, the Institute will have the coöperation of the Philco Corporation of Philadelphia. Under this coöperative course, selected students will spend alternate terms at the Institute and at the Philco plants.

"Twenty years' progress has been made in the field of electronics during the war emergency," declared Dr. Karl T. Compton, president of the Massachusetts Institute of Technology, in announcing the new course. "Tremendous opportunities will exist in all phases of electronics in applying wartime developments to the arts of peace, and the primary purpose of this new course of study will be to combine instruction in advance theory at M.I.T. with work in the plants of one of the leading companies in design and production of electronic equipment."

Boston Cocoanut Grove Fire Motivated This STS Research

Flame-Proofing Fabrics

by NANCY AGNES DURANT

At the age of 15, Miss Durant, then a student of the Dunbar High School in Washington, D. C., wrote this essay as part of her winning entry in the Third Annual Science Talent Search for the Westinghouse Science Scholarships. She is now a student at Radcliffe.

MY SCIENCE PROJECT is centered around the development of appropriate methods of flame-proofing paper and cloth. I was motivated into undertaking this project by the occurrence of the tragic "Boston Cocoanut Grove" fire, resulting from the use of inflammable decorations. This catastrophe brought the problem of flame-proofing to the mind of the entire nation.

While we were discussing the Boston fire in our chemistry class, I was assigned to the investigation of the relative merits of various materials which are known to impart fire-resistant properties to paper and cloth. Among the substances tested were aqueous solutions of (a) boric acid and borax, (b) boric acid and ammonium sulfate, (c) ammonium sulfamate, (d) ammonium chloride and ammonium sulfate, (e) potassium alum, borax, and boric acid, (f) ammonium chloride, (g) ammonium sulfate, (h) "Dupont Fire-Retardant," and (i) borophosphate resin.

The solutions were prepared carefully. Rayon cloth, cotton cloth, and filter paper were then immersed in the solutions. Four pieces of each type cloth and two samples of paper were used in each solution. One sample of cloth and one of paper were used as controls, that is, they were burned without treatment with the solution so as to provide some basis for judging the fire-resistant properties imparted by the substance being tested. The other piece of paper and one sample of each type cloth were burned after treatment with the solution. One sample of each type cloth was burned after dry cleaning and the last piece of each type cloth was burned after laundering.

The results of these tests were displeasing in that all of the solutions made the paper and cloth stiff. With the exception of the materials treated with ammonium sulfamate and the "Dupont Fire-Retardant" solutions, the non-inflammability of the treated materials was greatly reduced after dry cleaning. None of the cloth retained any noticeable flame-resistant properties after laundering.

When these findings were reported to my instructor, he suggested that I investigate the properties of other salts known to make materials flame-resistant. During this research, I found claims made for stannic (tin) salts and soluble tungstates. These claims reported the salts mentioned above to impart to cloth properties of flame-

resistance which remained after several launderings.

This phase of the research called my attention to many interesting properties of both these metals, especially tungsten. The extremely high melting point and the relative inactivity of tungsten would give it superior merit as a plating material. Further research revealed that the experiments already made with tungsten plating show that tungsten tends to produce oxides on the cathode during electrolysis of its solutions and indications are that tungsten must be co-deposited with another metal, iron or nickel.

The school storeroom contained no stannic compounds. However, there was plenty of metallic tin. Preliminary attempts to prepare stannic nitrate by using metallic tin and concentrated nitric acid yielded stannic oxide, stannous oxide, stannous nitrate and very small percentages of stannic nitrate in an almost inseparable mixture. The development of a suitable laboratory procedure for the preparation of stannic nitrate is still being worked out.

Looking up the preparation and properties of various tungsten salts, I found that sodium tungstate was the only tungsten salt suitable for making materials non-combustible and that it was prepared fairly easily. One method of preparing sodium tungstate calls for the use of tungsten trioxide and sodium hydroxide. While the sodium hydroxide was plentiful, the tungsten trioxide was not easily obtainable.

Our school is fairly large and we use many electric light bulbs each week. It is a simple matter to collect these used bulbs and to remove the tungsten filaments from them. Last spring the bulbs were broken by hand but this fall I developed a bulb-crushing machine as a project supplementary to the unit on mechanisms in the "Fundamentals of Machines" course. This machine consists of a toggle mechanism and a wheel, slotted arm, a sector of a spur gear, and a length of rack. The toggle mechanism crushes the bulbs and the toothed mechanism moves the base of the machine back and forth, freeing the filaments from the lead wires. If a machine of this type is used in connection with the salvage it would prove convenient, though costly, to dump the crushed bulbs into a container of concentrated nitric acid since this acid reacts with all of the metals in the bulb except the tungsten.

Large concerns have found the salvage of metal parts, other than the brass bases, of electric light bulbs impractical because of the expense of collection, freight, and salvage. However, if nitric acid can be obtained cheaply, the salvage of tungsten would probably be economical.

After the tungsten filaments are collected, they are heated to redness in an open crucible. $2W+3O_2 \rightarrow 2WO_3$. Under these conditions most of the tungsten is converted into tungsten trioxide which is then purified by the use of hot concentrated acid or aqua ammonia. Sodium tungstate is precipitated from the concentrated solution by adding the tungsten trioxide to the saturated solution.

$WO_3+2NaOH \rightarrow Na_2WO_4+H_2O$

The sodium tungstate precipitates out and is separated by filtration.

Another process for making sodium tungstate was developed by William

B. Stoddard and Irving Hochstadter and patented in March, 1922. This method of preparing the salt calls for the use of 500 parts of tungsten or tungsten ore, 330 parts of sodium nitrate, 75 parts of charcoal, 38 parts of sodium silicate solution and 13 parts of water. These ingredients are pulverized and mixed intimately. The mixture is then ignited. The sodium tungstate is recovered by lixiviation.

In these experiments the first process proved simpler than the Stoddard-Hochstadter method. Nevertheless, the Stoddard-Hochstadter method would probably be more economical in the commercial preparation of sodium tungstate since it does not require high temperatures or fuel costs.

Samples of paper, cotton cloth, and rayon cloth were treated with a 10 per cent solution of sodium tungstate. The treated paper was found to be flame-resistant to a high degree. Cotton and rayon cloth treated with the solution remained fire-proof after five dry cleanings. The cloth remained noticeably flame-resistant in spite of three launderings.

In the world of tomorrow there need be no tragedies similar to the Boston fire. Evening garments will be flame-proofed and one flame-proofing will last the life of the garment. "Flame-Proof" and "Fire-Resistant" will be seen on clothing labels tomorrow just as often as "Water-Proof," "Water-Repellent" and "Sanforized" appear on such labels today. "An ounce of prevention is still worth a pound of cure." Flame-proofing will be that ounce of prevention.

Floating Refrigerators in South Pacific

➤ THERE'LL BE ice cream, fresh meat, cheese, and eggs for American soldiers stationed in the Pacific war theater, brought to them in a new type of barge the Army has built for the purpose, the War Department reports. Three floating refrigerators, each costing $1,120,000, can store 64 carloads of frozen meats at 12 degrees above zero in the eight main holds. Two main deck compartments each have a capacity of about 500 measurement tons of fresh vegetables, cheese, eggs, and other perishable produce.

In addition, each barge has a special unit that turns out 10 gallons of ice cream every seven minutes and a plant that manufactures five tons of ice a day. The barge's elaborate cooling machinery is operated by 84 electric motors with capacities up to 150 horsepower. A complete change of arctic air is provided every four minutes to all chill and freeze compartments by 12 blowers.

The barges have flat-bottomed concrete hulls, are 265 feet long with a 48-foot beam and a 12- to 15-foot draft. They carry a crew of 10 men and 13 officers. The floating refrigerators will operate only in the southwestern and western Pacific. Small boats, operated by the Transportation Corps, will pick up the cargo and deliver it to troops, on an inter-island service.

There is almost as much zinc as there is iron in the human body.

One of the "Scientists of Tomorrow" Writes About Wild Plants He Gathered

Research in the Drug Industry

by GILBERT SAMUEL DANIELS

When this was written as one of the essays of the Third Annual Science Talent Search for the Westinghouse Science Scholarships, the author was 16 years of age and a student of the Brooklyn Technical High School, Brooklyn, N.Y. After having been one of the STS winners and participated in the 1944 Science Talent Institute, Mr. Daniels is now studying at Cornell University.

GEORGE WASHINGTON CARVER believed that men should utilize the materials at hand and not turn to other sources until the native resources had been fully exploited. It is unfortunate that it takes a war to make many people realize the sound basis of such a policy.

I have always been fascinated by stories like *Robinson Crusoe*, wherein a man is forced to be self-sufficient. For many years I avidly read Jules Verne's *Mysterious Island* over and over, absorbing the details of the independent life of the castaways on the island.

Happily I can say that my adventures in the field of self-reliance have not been limited to fiction. Last year I collected and sampled over fifty edible wild plants of lower New York State. The number of common plants found along the wayside and in the woods with edible qualities proved surprising to me as my collection grew. By the end of the summer I was able to find edible plants without any effort in even such seemingly barren places as city back yards.

My botanical interests are, however, not limited to the field of gastronomy. As I hope some day to find a place in the medical profession I am interested in pharmacognosy as well, and like George Washington Carver, I too am attracted to the native plants of the United States rather than to those of other lands.

In the course of following this field of endeavor I have come across a number of facts about the drug industry which are rather surprising. First, the great number of plants in the United States with medicinal value is quite startling. Second, only comparatively few of these have ever been subject to the scrutiny of modern research. And third, the methods of preparation of drug plants now in use do not insure uniform dosages and consequently uniform results in many cases cannot be assured.

Research in these fields would be a great boon to the medical profession. A thorough survey of the North American flora with medicinal value would establish a definite knowledge of the possible domestic sources of crude drugs. Eventually this would tend to eliminate the rather confusing changes that take place on the official drug lists from time to time in regard to just which plant is the official source of any one particular drug.

The very fact that the official source of a drug should be limited to one plant leaves room for criticism. Under our present drug system this limitation is unfortunately absolutely necessary. The drugs are usually used in the crudest possible form in which they may be safely and conveniently administered. Because of the variation of concentration of the active ingredients in different species of plants containing the same drug, plus the presence of different impurities, the drug must be limited to one source if it is to be used in a crude form so that the results will be fairly similar in all cases.

Even under this system the effect produced is not the same in all cases, due to the variation of concentration of active ingredients in the same species of a plant, depending upon the environmental conditions under which the individual plants have grown.

One of the best ways of overcoming this difficulty would be to standardize the use of extractions of known concentration of active ingredients only. Here again research would come into the picture as new methods of extraction would have to be devised.

In addition this use of pure active ingredients would not only allow the use of a wider variety of plants as a drug source but would also enable science to make better use and greater use of such a drug as Cannabis. This drug, found in the Indian hemp or marihuana plant *(Cannabis sativa)*, is used rarely at the present time due to the uncertainty of reaction caused by the great variation of undesirable impurities found in the plant along with the Cannabis and also to the great variation of the concentration of the drug itself in the plant due to varying climatic conditions.

It is interesting to note that some work was done with native drug plants and their utilization in the Confederate States during the Civil War. One of the diseases prevalent in the South was malaria and due to the war foreign sources of quinine were cut off from the Confederates. They turned in their need to the bark of the flowering dogwood *(Cornus florida)* as a substitute and found it successful against the fever. The bark of this dogwood is known even today as one of the best substitutes for quinine. There are a number of other species of *Cornus* found in North America and they all most likely have similar qualities but it is up to research to find out definitely the usefulness of these plants.

In line with this research we should not overlook the oldwives' remedies which are a part of nearly every household in this country. Many of these remedies are mere superstition but many have a sound basis of medical fact. Nowadays we tend to scoff at such cures but a thorough investigation of the ingredients of these remedies would not be without value in bringing to the attention of the research worker many native plants of actual medicinal value.

I personally had an experience with one of these remedies last summer. While making my collection of edible wild plants I made it a point to ask all the farmers of the area if there were any plants growing wild of which they made use. One old fellow told me that his father had used an infusion of boneset *(Eupatorium perfoliatum)* to

treat head colds but that he thought it was just superstition and was of no real value. I found out later that boneset is officially listed as a treatment for head colds.

These are but a few examples of the wide fields of research yet to be explored in medical botany. At the present time I can do little more than delve into old books and make oral inquiries. I hope, though, some day to be among those who carry out the research which will bring about great changes in the treatment of man's ills.

Disease Follows Weed Killer Use

➤A SAD STORY of ill consequences following an effort by farmers to do good in their fields is told by Dr. John T. Middleton of the California Experiment Station. A disease of tomato plants that seemed to be a kind of mosaic appeared in certain California tomato fields. Leaves were mottled, fruits few in number and small in size. However, efforts to reproduce it by inoculating other plants with juice from diseased specimens were unsuccessful.

When a checkup was made of the history of the fields in which the trouble occurred, it was learned that in every case a chemical weed-killer, sodium chlorate, had been used at some time in the past in an effort to control bindweed, one of the worst of plant pests. The more recent the treatment, the more severe were the symptoms on the tomato plants. However, effects were noted when the last application of the chlorate had been made five years previously.

Redder Apples from Greener Leaves

➤ THE REDDER the apples the better they sell. But the right shade of green in the apple-tree's leaves is an indicator of how red the apples will be, since healthy dark-green in leaves and lively red in apple skins both result, in part, from proper adjustment in the amount of nitrogen fertilizer fed to the tree.

Working on this principle, two Cornell University faculty members, O. C. Compton and Prof. Damon Boynton, made careful laboratory studies of the color of leaves collected in midsummer from trees under different nutritional conditions. Using their spectrophotometer data a New York City research corporation made up a set of seven carefully compounded printing inks, with which a chart of seven leaf-green shades has been prepared. Now all an apple-grower needs to do is hold the chart alongside sample leaves from his trees, and he will get an idea of how things stand with their nitrogen nutrition.

In general, high nitrogen produces apples of large size but poor color; and since color is the deciding sales factor a compromise must be sought between color and size.

The work of the two Cornell researchers has thus far been confined to one apple variety, the McIntosh. However, since about half the apples raised in New York are of this variety, their studies are considered of particular importance for this state.

Latest Inventions and Discoveries Given Patents

Chemistry in New U.S. Patents

WEEK BY WEEK *as the Patent Office Gazette officially announces the new patents granted, there are many that are important to the science and technology of chemistry. For information about any patent you may obtain the complete patent by sending 10 cents in coin (not stamps) to the Commissioner of Patents, Washington, D. C., and asking for the patent you wish by number.*

Polyvinyl Alcohol

➤ YOUR POSTWAR FLIVVER—whether it flies on wings or rolls on wheels—is likely to come to you tightly coated with a scratch-proof transparent film that can be easily peeled off. That is a logical peacetime extension to expect of U. S. patent 2,372,982, just issued to A. B. Richards, J. A. Mickey and J. T. O'Reilly, all of Dearborn, Mich., and assigned by them to the Ford Motor Company.

The protective coating, now intended primarily for use on the transparent plastic noses and turrets of fighting planes, consists of polyvinyl alcohol dissolved in water, with small amounts of a chemical wetting agent and glycerin added. The parts to be protected are dipped in the solution, or the coating may be sprayed or brushed on. Once dried, it sticks tight, giving protection against rubbing and scratching; however, a slight break anywhere will permit ready peeling. A thread, tab or other device may be incorporated as a rip-starter. The solution may also be colored, so that the extent of its coverage can be seen at a glance.

New Gasoline Feed

➤ ANOTHER new patent having to do with motor mechanics is No. 2,372,-700, granted to Arthur C. Allen of Chicago, and assigned to the Stewart-Warner Corporation. It is on a gasoline feed system for automobiles, which is operated by the pressure of the engine exhaust.

An input tube leads from the muffler under the car to the gasoline tank at the rear. An automatic valve permits the building up of pressure in the tank to two pounds per square inch above atmospheric pressure; then, to prevent back-pressure against the engine, the air stream is shunted to the outside. The feed line runs directly from the tank to the carburetor. Means for condensing water vapor and trapping it out are also provided.

Motor Fuel Electrolysis

➤ A BOLD BID to make motor fuel cheap by cracking water into oxygen and hydrogen and then recombining them is represented in patent 2,373,-032, obtained by Bernard Klein of Baltimore. Mr. Klein has an electrolytic device which he holds to be more practicable than those hitherto tried for this purpose. It consists of a relatively long horizontal cylinder, with electrodes in its opposite ends, and baffle plates to prevent undue sloshing

of the liquid and to keep the gases separated. Acidulated water is fed in near the middle, and the gases are led out through the end chambers.

Welding Plastics

➤ PLASTICS join metals as materials for the welder's art, with a proper tool for the purpose being provided by W. M. Phillips, Jr., of Detroit, under patent 2,372,737. Instead of flame or an electric arc, Mr. Phillips' torch directs a jet of very hot air along the seam or joint to be welded, and follows it with a roller to smooth the job down. The air is brought to the proper temperature by being passed through a long coil of electrically heated Nichrome wire. Rights in the patent are assigned to the Udylite Corporation, of Detroit.

Gas-Masks from Weeds

➤ STRAW and other farm wastes, even stalks of wayside weeds, can be put to good use in protecting the lives of our fighting men if an enemy resorts to poison-gas warfare. Two U. S. Department of Agriculture chemists, Dr. E. C. Lathrop and S. I. Aronovsky, of the Northern Regional Research Laboratory at Peoria, Illinois, have been granted U. S. patent 2,372,437 on a gas-mask filter medium in which short cellulose fibers from straw and other neglected materials play an important part.

Long fibers of alpha cellulose, from wood pulp or cotton linters, are standard constituents of such filters, the two inventors explain. However, they require the addition of shorter fibers to increase their adsorbent capacity. Short asbestos fibers can be used, but these are difficult to separate out from the general mass of asbestos and hence are comparatively costly. This objection does not apply to the short, highly adsorbent fibers of alpha cellulose that can be obtained in abundance from straw and stalk materials.

Rights to manufacture and use the newly patented filter medium are assigned royalty-free to the government, through the Secretary of Agriculture.

Magnesium, Steel and Cement

➤ A PROCESS that yields magnesium, alloy steel and cement from the same operation is the subject of patent 2,372,571, issued to Dr. Fritz J. Hansgirg, Austrian-born metallurgical chemist who since 1940 has been in this country where, among other jobs, he aided Henry Kaiser in setting up his big magnesium plant at Permanente, Calif.

Dr. Hansgirg's new process is designed to make use of silica-containing ores of magnesium, such as serpentine, olivine, etc. The mineral is finely powdered, mixed with calcium carbide and compressed into tablets. These are heated in a retort, under vacuum. The magnesium is driven off as a vapor, which on cooling yields the metal in solid, pure form. The slag or clinker contains fine particles of alloy steel, rich in chromium and titanium; sometimes iron ore must be added before processing, if the natural mineral does not contain enough iron. The steel particles are extracted with a magnetic separator, and the silicious residue goes to the cement mill.

"Makings" of PETN

➤ PRODUCTION of the raw material for PETN, powerful and sensitive high explosive, from two common chemicals is covered in patent 2,372,602,

which G. R. Owens of Dayton, Ohio, has assigned to the Monsanto Chemical Company. The two ingredients are formaldehyde and acetaldehyde; combined in the presence of an alkali (usually lime) at a carefully controlled hydrogen ion potential, these become pentaerythritol. The tetranitrate of the latter compound is PETN.

Electron Microanalyzer

➤ AN ELECTRON microanalyzer was developed by Dr. James Hillier at the RCA Laboratories, Princeton, N. J., who has assigned rights in patent 2,372,422 to the Radio Corporation of America. The instrument, an adaptation of the electron microscope, directs an exceedingly slender stream of electrons against minute spots on metals or other materials to be analyzed; the spectrum of the reflected high-frequency rays tells the chemical story.

Fruit Waxer

➤ A MACHINE for applying decay-preventing wax coatings to fruits and vegetables won S. C. Rieke of Mission, Texas, patent 2,372,225. The fruit is passed along over a series of roller-shaped wire brushes. Particles of wax are shaved off a solid wax bar in a holder; these are converted into liquid drops by a blast of hot air from a fan, and the drops fall in an atomized spray, to cover the rolling fruit.

Detecting Poison Gases

➤ A NEW METHOD for detecting small amounts of poison gases in the air, claimed to be quicker and more sensitive than those hitherto tried, has been made the subject of three new U. S. patents, Nos. 2,373,111 to 2,373,113 inclusive, by a retired Marine Corps officer, Maj. Oliver T. Francis. Rights to manufacture and use are assigned royalty-free to the government.

Basis of Maj. Francis' method is the fact that dissolved substances change the electrical conductivity of the water or other liquid in which they are dissolved. Since some of the most dangerous of the poison gases are only slightly soluble in their normal state, he first passes the stream of air to be analyzed through an electrically heated tube, which changes the make-up of the gas molecules and renders them soluble. Then they are passed into water or some other solvent, samples of which are passed through a slender tube between two spaced electrodes. Changes in the current flow are detected by head-phones, microammeter or other suitable means. The method is usable not only in the field but in factories and arsenals where gas leakages might become dangerous.

Gasoline Inhibitors

➤ IMPROVEMENT in the storage properties of leaded aviation gasoline is the achievement on which patent 2,373,631 was awarded to John E. Mital of Alton, Ill., assignor to the Shell Development Company of San Francisco.

The gasoline used as the basis for leaded aviation fuel keeps well in its natural state, Mr. Mital explains. Addition of the anti-knock lead reagent, however, provokes rather rapid deterioration, resulting in gumminess and precipitation of some of the lead. To offset this, inhibitors are also added, amino phenols being especially successful. Mr. Mital has now dis-

covered that adding hydrobromic or hydriodic acid to the inhibitor makes it even more efficient, and it is on this that he has obtained his patent.

Fruit Juice Concentrates

➤ CONCENTRATED and sterilized fruit juices can be prepared by a process that does not unfavorably affect their flavors, as happens sometimes in the current practices that involve heat treatment. U. S. Patent 2,374,219 has been issued here on the new process, to Royal Lee, of Milwaukee.

Instead of heating the juice to get rid of excess water, Mr. Lee freezes it. This converts most of the water into ice, at the same time trapping pulp and other undesired solids. The icy mass is then crushed, and the unfrozen, concentrated juice is centrifuged out.

The inventor proposes several methods for sterilizing the juice. One of the most ingenious is the addition of germ-killing chemicals like toluene or methanol. These are poisonous, but they never reach the consumer, for they are also volatile, and they are evaporated out by gentle warming in a vacuum pan or a spray chamber before the final product is bottled or canned. The low-temperature evaporating step may be carried to the point of preparing a solid instead of a concentrated liquid or syrupy product.

Liquid "Fuze"

➤ A WAR invention, patented (No. 2,373,883) by Clyde B. Ferrel of San Francisco, is reminiscent of the dynamite-filled bullets that wrecked the London-raiding Zeppelins during World War I, except that it is applied to cannon shells instead of machine-gun bullets. The inventor proposes to fill the shell cavity with a bag of nitroglycerin jelly cushioned against a rubber pad in the base. The neck of the bag projects through an opening in the nose, and is folded back to cover the end of the shell. The thrust of firing squeezes a little of the liquid nitroglycerin out through the nose, and when this ultra-sensitive stuff touches any obstacle, even the thinnest of airplane fabric, it will detonate the whole charge.

Rubber Wallboard

➤ THE STALKS of rubber-containing plants are pulped up, and the natural rubber content is used to cement the material into wallboard, in the process described by Paul Kenda of San Antonio, Texas. Patents 2,373,689 and 2,373,690 cover, respectively, methods for doing this with guayule shrubs and poinsettia plants—the latter grow like weeds in the Texas climate.

New Alloy

➤ A NEW light-metal alloy is put forward by R. H. Harrington of Schenectady, N. Y., for patent 2,373,678. It consists mainly of aluminum, with small percentages of copper, cobalt and beryllium, which give it greatly increased strength. Patent rights are assigned to the General Electric Company.

Fat in Food

➤ PACKING fat-containing foods in dry condition has always been a difficult problem. Fred H. Barker of Los Angeles has developed a process for incorporating rendered fat into a mass of dried powdered vegetables, plus

seasoning, and perhaps gelatin from bones, hardening the paste thus formed, and grinding it up into granules. The product is claimed to be usable in soups and for similar purposes. Patent 2,373,805 was awarded the process.

Micro-Method for Paint

➤ A MICRO-METHOD for the exact study of paint films under various types of exposure is the subject of patent 2,373,104, issued to Ferd Dieffenbach of Greentree, Pa., a civilian employe of the War Department. Glass microscope slides are dipped in the paint or drying oil to be tested, then permitted to dry. They are then immersed in fresh or salt water, and at intervals taken out and placed on the stage of a microscope. Two light sources are turned on them: one beam strikes upward at an angle from beneath, the other is thrown exactly at the edge of the slide. Wrinkles, holes and other surface changes are brought out in strong relief. Rights in the patent are assigned royalty-free to the government.

Steel Protection

➤ FOR THE PROTECTION of ultra-hard alloy tool steels during induction hardening, Raymond S. Wile of Flushing, N. Y., has developed a coating of graphite suspended in oil. When this is applied, steel tools may be induction-hardened in as little as six or seven seconds at temperatures of from 1800 to 2300 degrees Fahrenheit, without danger of oxidation. Patent 2,374,634 was awarded this new method.

Paper Conducts Electricity

➤ PAPER that will conduct electricity, desirable in certain technical applications, is the subject of patent 2,374,214, granted to B. L. Kline, Manhasset, N. Y., and C. E. Mobius of Brooklyn, assignors to the Western Union Telegraph Company. Aluminum powder is mixed with the paper pulp in the process of manufacture. This has been done before, the inventors state, but difficulty was encountered through the formation of non-conducting coatings of oxide on the particles. This they now prevent by the addition of some of the solid higher alcohols or other related compounds.

Vitamin K

➤ MAKING synthetic vitamin K (hemorrhage-preventive) more stable chemically by converting it from a quinone to a hydroquinone is covered by patent 2,373,105 granted to Prof. E. A. Doisy and associates of St. Louis University, and assigned to the university.

Iron Salvage

➤ REDUCING loss of iron in blast furnace flue dust by working the salvaged dust into gummy lumps with molasses, glucose or the like and charging them into the furnace along with the ore won Frank Holz of Cleveland patent 2,373,244.

Magnesium Flotation

➤ FLOTATION process for the benefaction of low-grade magnesium ores, on which patent 2,373,123 was granted to John W. Lefforge of Columbia, Tenn., has been assigned royalty-free to the government. The pulverized ore is first freed of talc by floating it off with pine oil; then the magnesite is floated off with oleic acid.

Radio Drying

➤ USE OF high-frequency radio waves

for drying filaments of viscose and other synthetic textile materials is covered by patent 2,373,374, issued to R. A. Bierwirth of Kingston, N.J., and assigned to the Radio Corporation of America.

Electronic Vulcanization of Rubber

➤ THE ELECTRONIC vulcanization of rubber may become common in the near future, replacing the familiar heating method, with the securement here of the basic patents covering the new process granted on discoveries made by R. A. Dufour and H. A. Leduc of France, and by E. E. W. Kassner of Switzerland. The purchasers of the patents are the B. F. Goodrich Company and the Firestone Tire and Rubber Company, who plan to make them available to other companies in the rubber and plastics industries on a reasonable basis.

Electronic vulcanization will speed production, but, more important, will give more uniform and higher quality products. Vulcanization is the joining of rubber molecules and sulfur. For more than a century, rubber has been vulcanized by applying heat to the outside surface. Since rubber insulates against rather than conducts heat, heating to the core by this method is slow and lacks uniformity. In electronic heating the core is heated quickly. In electronic vulcanization, high-frequency oscillations shake the molecules of rubber and sulfur millions of times a second, creating uniform heat throughout the product being vulcanized in a fraction of the time required when steam heating is used.

Selenium Improves Lubricants

➤ LUBRICATING OILS are found to be improved by the addition of small amounts of compounds of selenium, a non-metallic chemical element of the sulfur-tellurium group, as a result of investigations recently completed by the Battelle Memorial Institute at Columbus, Ohio. The selenium compounds impart many desirable features to the oil, including the ability to resist its tendency to oxidize and form sludge and gummy resins in the engine. A film of selenium-treated oil will support increased pressure between surfaces.

Selenium is usually found associated with sulfur in metallic sulfides. Discovered in 1817, it was long regarded as a waste product in the copper industry but later several important uses were found for it. Selenium colors glass a rose-red and so can neutralize the green tint of ferrous impurities. Red signal glass is made with it. Selenium insecticides are used, but they are toxic to some plants; and foods grown on soils containing selenium have toxic effects on animals.

Selenium is used also in radio and electronic equipment, the toning of photographic prints, the making of free-machining alloys, and the barnacle-proofing of ship hulls. Its beneficial use in lubricants will improve its position in the chemical world.

Ounce of Avoidance
Worth Quarts of Cure

Poison Ivy Facts

by Dr. Frank Thone
Science Service Biology Writer

▶ Ivy poisoning continues to be a wholesale seasonal affliction—almost like a recurrent epidemic disease!

Poison ivy victims begin to become numerous at about this time of year, and they will continue so until frost strips the wicked vine of its foliage. It is sometimes stated that poison ivy is at its most virulent when in bloom; but most of the afflicted ones can find no seasonal differences in their miseries. Just as many blisters and as much itching in summer as in spring, they declare.

The malaise of ivy poisoning—ranging from relatively mild discomfort in some to acute and prolonged suffering in the more sensitive—can be largely obviated by attention to a few simple precautions. As in all afflictions, prevention is better than cure, and avoidance of the cause is the key to prevention. Learn to recognize poison ivy at sight, and keep away from it whenever you see it, and you will reduce the number of attacks per season—perhaps eliminate them altogether.

Poison ivy is easily recognizable by its three-parted compound leaf. It is the only abundant shrubby plant in the woods with that kind of leaf. Flowers are small, greenish-white, thickly clustered; they are followed by berries that become a slightly soiled parchment-white when ripe.

For the Eastern species, there is no valid distinction between poison ivy and poison oak, which is sometimes attempted on the basis of leaflet-shape. Leaflet margins range all the way from entire to deeply notched or lobed—sometimes on different parts of the same vine. Poison ivy is an exceedingly variable species. The name poison oak is properly applied to the Western species, which is plentiful in the foothills of coastal mountain ranges, and is also found less abundantly inland.

Properly speaking, poison ivy is a vine. In humid woodlands it climbs

trees and clambers over rocks and stone fences, clinging by means of innumerable aerial roots. In slightly drier terrain, it disguises its character by running the main stem of the vine along or just under the ground surface, sending up numerous branches that range from a few inches to four or five feet in height, so that it is often described as a shrub. But it's all the same old pesky poison ivy.

Several hundreds of remedies for ivy poisoning have been proposed, almost all of them completely worthless. A few years ago U. S. Public Health Service scientists developed an ointment containing 10% sodium perborate and 2% potassium periodate in a cold cream base, which is said to be very effective in most cases. It has, however, the drawback of losing its strength in about two weeks, so that it has to be made up fresh very frequently.

There is also a good preventive treatment, which persons who know themselves to be susceptible can put on before going into the woods. It consists simply of a 5% solution of ferrous sulfate in a half-and-half mixture of water and ethyl alcohol; a little glycerin may be added to keep it from feeling too dry as it evaporates on the skin.

Oil Sprays Kill Weeds

▶ CERTAIN PAINT-THINNER OILS sprayed on weeds in a carrot or parsnip garden kill the weeds effectively without injury to the vegetables, according to J. R. Hepler of the University of New Hampshire in a recent statement reviewing experimental work at two agricultural colleges, the Massachusetts State College and Cornell University. Sovasol No. 5 and No. 75, distributed by the Standard Oil Company of New York, were used. The first is widely used as a paint-thinner and for dry-cleaning clothes, the second is also a paint-thinner.

When Sovasol No. 75 was used, it was found necessary to thin it with white kerosene or stove oil; otherwise it burned the vegetables severely. With two parts of the kerosene to one part of the oil no burning occurred.

The best time to spray, it was found at the Massachusetts institution, is when the weeds are very small. When they were from five to six inches high, the spraying treatment was not effective. Small weeds wilted within an hour of treatment.

The spray should be applied with a flat nozzle, it was found, rather than with a circular nozzle. Approximately 80 gallons of oil spray per acre are needed.

The Cornell investigators found that carrots, celery, celeriac and turnip-rooted parsley were quite tolerant to oil sprays, but that such crops as beets, lettuce, onions, and spinach, among others, were susceptible to injury. They determined that the oil sprays can be used with safety with all members of the parsley family, which includes carrots, parsnips and celery.

Common salt is used in large quantities in rolling mills in the rolling of steel plates, to help break the scales from the surface of the steel slab.

Important Element Kills Germs, Bleaches Cloth, Enters Into Compounds

Chlorine, Salt Shaker Chemical

Second of a Series on Basic and War Chemicals.

by Dr. C. M. A. Stine

Vice-President Advisory on Research and Development, E. I. duPont de Nemours & Co.

To most people chlorine means a good chemical with a bad taste, something that kills germs and makes city water safe to drink and swimming pools safe to swim in.

To many veterans of World War I chlorine is remembered as a yellowish green cloud rolling in from the German lines at Ypres to kill thousands of unsuspecting and unprepared Allied soldiers. It was the first war gas.

But to the chemist, chlorine is one of the most useful elements—for peace or war—in the whole list of 92. It is useful alone, as well as in partnership with many other elements. It is, for example, the Cl part of NaCl, which is sodium chloride, or ordinary table salt. And from the tons of salt, packed away in Nature's subterranean storehouses, the chemist draws chlorine for its thousands of chemical jobs. Ten billion pounds of salt, yielding sodium as well as chlorine, are consumed by chemical manufacturers in a single year. This doesn't count the salt consumed as salt on America's eggs, steaks, stringbeans, mackerel and spinach.

Electric power is the key which unlocks the sodium chloride molecule and separates the sodium from the chlorine. Most of the large chemical companies harness electric energy for this electrolytic task. Salt in almost pure crystals from American mines is first freed from impurities. Then, in one process, it is melted and placed in great tanks. Immersed in each tank are two electrodes, one positive and one negative. The sodium chloride separates into sodium and chlorine ions (electrically charged atoms). The sodium ions migrate to the negative electrode, and are drawn off in the form of hot, molten sodium. The chlorine ions travel to the positive electrode and are piped off as chlorine gas.

At last released from its bondage to sodium (a bondage of millions of years duration) chlorine starts off on its new career, traveling in railway tank cars or small cylinders to water purification or sewage disposal plants or to one or another of hundreds of chemical jobs. As a safeguard against sabotage efforts to contaminate water supplies, many American cities have doubled the chlorine content, which, of course, tremendously increases the demand for this chemical.

Water works, sewage plants and public swimming pools are still preferred claimants for chlorine's purifying services, since these services are necessary to protect the nation's health. But the War Production Board has ordered the textile industries to use only half as much chlorine as usual in the bleaching of cloth, including that destined for Army and Navy uniforms, and has cut the laundries down to ten per cent of their former consumption. Paper manufacturers also have to get

along with less of this universal whitener. Meanwhile chlorine production capacity has been doubled since 1939.

One reason for rationing the textile and laundry and paper people is that chlorine is urgently needed as an ingredient of neoprene synthetic rubber. In the making of this essential material chlorine is combined with carbon and hydrogen in intricate reactions carried out in highly elaborate and costly manufacturing plants. Neoprene, of course, is used in tanker hose, barrage balloons, life belts, life rafts and pontoons, "exposure suits" to protect aviators forced down over water, protective jacketing for ship cables, airplane wiring and Army field telephone lines, and hundreds of other articles required to "keep 'em rolling, sailing and flying." Chlorine also enters into compounds used to make antiknock ethyl compound for gasoline, used in cars, trucks, tanks and airplanes.

Another big defense job performed by the chlorine half of the salt molecule is known as "degreasing." Here the chlorine teams up with such elements as carbon and hydrogen to make various cleaning fluids—carbon tetrachloride, perchlorethylene and trichlorethylene. In peace-times these fluids are used to clean clothes as well as metals. But today's rapid production of machine guns, airplane motors and other machines of war requires greatly increased quantities of degreasing fluids. Before any metal article can be plated, lacquered or painted it must be completely free of grease or oil. Otherwise the plating or finish would flake or peel off, with consequent rust, corrosion or undue wear on the underlying metal. A clean piece of war metal is more important than a spotless vest, so most of the cleaning fluid goes to the metal plants.

Finally, chlorine bleaches the cotton linters before their conversion into gun-cotton to hurl bullets and shells against the enemy.

So, as you shake a little NaCl upon your scrambled eggs give a nod of respect to the hidden giant in the salt molecule, the mighty atom of chlorine.

Synthetic Rubber No Longer Just Substitute

➤ SYNTHETIC RUBBER is here to stay on its own merits, and it will no longer be used merely as a substitute for natural rubber, reports E. F. Riesing, chairman of the National Division of Rubber and Plastics of the American Society of Mechanical Engineers, and chief automotive engineer of Firestone Industrial Products Co.

He pointed to the superiority of the synthetics in specific physical properties such as resilience, efficiency, low-temperature flexing, low-temperature brittleness, high-temperature stability, oil resistance, resistance to ultraviolet rays, ozone, acid, gas diffusion and other important properties.

The facts presented by Mr. Riesing were based upon extensive tests simulating temperature conditions in the African desert and in Alaska. One type of synthetic rubber, a polybutadiene compound, will not freeze or become brittle under substratosphere low-temperature conditions. This particular type of rubber freezes at 100 degrees below zero Fahrenheit.

Discovery of Radium as Announced by the Curies

Strangest of Elements

A Classic of Chemistry

➤ LAST of the alkaline earths, radium is the most glamorous of elements. Everything about it calls for superlatives. Its scarcity is unbelievable, its energy amazing. Although actually the fourth radio-active element to be discovered, one thinks of it as the type of them all. Its rays, which make its compounds glow beautifully in the dark, cause dangerous burns, yet are used to treat cancer, most dreaded of diseases. The idyllic love story and personal tragedy of its discoverers add to the epic quality of the story of radium.

For the classic on radium we quote the first two communications announcing its discovery. The first tells the reasons for suspecting the presence of a new element in the ores Marie Curie was examining. The second gives confirmation of the fact that an unexpected analogue of barium was present in the material, although in such small amount that it could not then be isolated. The reader will be interested to note the characteristic phrases, "One of us . . .", "Two of us . . .", by which Marie and Pierre Curie avoided the necessity for individual claims to the work they did together.

Radioactivity

RAYONS ÉMIS PAR LES COMPOSÉS DE L'URANIUM ET DU THORIUM (Rays emitted by compounds of uranium and thorium). Note de Mme. Sklodowska Curie[1], présentée par M. Lippmann. Comptes Rendus, T. 126, April, 1898. Translated for CHEMISTRY *by Helen M. Davis.*

➤ I HAVE STUDIED the conductivity of air under the influence of the rays from uranium, discovered by M. Becquerel, and I have sought whether any other bodies than those composed of uranium are able to render air a conductor of electricity. I used for this study a plate condenser; one of the plates was covered with a uniform layer of uranium or another substance finely pulverized. (Diameter of the plates 8 cm.; distance 3 cm.). A difference of potential of 100 volts was established between the plates. The current which passed through the condenser was measured in absolute value by means of an electrometer and a piezo-electric quartz.

I have examined a great number of metals, salts, oxides and minerals[2]. The Table given below gives, for each substance, the value of the current i in amperes (of the order of 10^{-11}). Materials which I have studied which do not appear in the Table are at least 100 times less active than uranium.

Table

	Amperes
Uranium, slightly carbonated	24 x 10^{-12}
Black oxide of uranium, U_2O_5	27 "
Green oxide of uranium, U_3O_8	18 "
Uranates of ammonia, potassium, sodium, about	12 "
Hydrated uranic acid	6 "
Uranyl nitrate, uranous sulfate, uranyl and potassium sulfate, about	7 "
Artificial chalcolite (copper and uranium phosphate)	9 "
Thorium oxide in a layer 0.25 mm thick	22 "
Thorium oxide in a layer 6 mm thick	53 "
Thorium sulfate	8 "
Potassium fluoxytantalate	2 "
Potassium fluoxyniobate and cerium oxide	0.3 "
Pitchblende from Johanngeorgenstadt	83 "
Pitchblende from Cornwall	16 "
Pitchblende from Joachimsthal and from Pzibran	67 "
Natural chalcolite	52 "
Autunite	27 "
Various Thorites	from 2 to 14 "
Orangite	20 "
Samarskite	11 "
Fergusonite, monazite, xenotime, niobite, aeschinite	from 3 to 7 "
Cleveite, very active.	

All the compounds of uranium studied are active and they are, in general, the more active the more uranium they contain.

The compounds of thorium are very active. The oxide of thorium even exceeds metallic thorium in activity.

It should be noted that the two most active elements, uranium and thorium, are those which have the greatest atomic weight.

Cerium, niobium and tantalum seem to be slightly active.

White phosphorus is very active, but its activity is probably of a different nature than that of uranium and thorium. In fact, phosphorus is not active either in the state of red phosphorus or of the phosphates.

The minerals which have shown themselves active contain active elements. Two ores of uranium, pitchblende (uranium oxide) and chalcolite (phosphate of copper and uranium) are much more active than uranium itself. This fact is very remarkable and leads to the belief that these minerals may contain an element much more active than uranium. I have produced chalcolite by the process of Debray from pure materials; this artificial chalcolite is no more active than any other salt of uranium.

Absorption.—The effects produced by active substances increase with the thickness of the layer used. This increase is very feeble for compounds of uranium; it is considerable for the

oxide of thorium which seems to be partly transparent to the rays which it emits.

To study the transparency of different substances, a thin plate of one of them is placed over the active layer. The absorption is always very great. Nevertheless rays pass through thin sheets of metal, glass, ebonite, and paper. The fraction of rays transmitted by aluminum foil 0.01 mm thick is:

mm

0.2 for uranium, ammonium uranate, uranous oxide, artificial chalcolite.

0.33 for pitchblende and natural chalcolite.

0.4 for thorium oxide and thorium sulfate 0.5 mm thick.

0.7 for thorium oxide 6 mm thick.

It is evident that compounds of the same metal emit rays absorbed equally. The rays emitted by thorium are more penetrating than those emitted by uranium; also, thorium oxide in a thick layer emits much more penetrating rays than it emits in a thin layer.

Photographic impressions.—I have obtained good photographic impressions with uranium, uranous oxide, pitchblende, chalcolite, and thorium oxide. These bodies are active at a short distance to pass through either air or glass or aluminum. Thorium sulfate gives weaker impressions and potassium fluoxytantalate very weak impressions.

Analogy with the secondary rays of Röntgen rays.—The properties of rays emitted by uranium and thorium are very analogous to the secondary rays of Röntgen rays, studied recently by M. Sagnac. I have proved especially that, under the action of Röntgen rays, uranium, pitchblende and thorium oxide emit secondary rays which, from the point of view of the discharge of electrified bodies, have generally more effect than the secondary rays of lead. Among the metals studied by M. Sagnac, uranium and thorium would be placed beside or beyond lead.

To interpret the spontaneous radiation of uranium and thorium one might imagine that all space is constantly traversed by rays analogous to Röntgen rays but much more penetrating and able to be absorbed only by certain elements of high atomic weight, such as uranium and thorium.

[1] This work was done at the Municipal School of Industrial Physics and Chemistry.

[2] The uranium used for this study was donated by M. Moissan. The salts and oxides were pure compounds, tested at the laboratory of M. Étard at the School of Physics and Chemistry. M. Lacroix was kind enough to get me some mineral specimens of known composition, from the collection of the Museum. Some rare and pure oxides were given by M. Demarçay. I wish to thank these gentlemen for their kindness.

Radium

SUR UNE NOUVELLE SUBSTANCE FORTEMENT RADIO-ACTIVE, CONTENUE DANS LA PECHBLENDE[2]. *(On a new strongly radio-active substance contained in pitchblend). Note de M. P. Curie, de Mme. P. Curie et de M. G. Bémont, présentée par M. Becquerel. Comptes Rendus, T. 127, December, 1898. Translated for* CHEMISTRY *by Helen M. Davis.*

➤ Two OF US have shown that, by purely chemical processes, it is possible to extract from pitchblend a strongly radio-active substance. This

substance is closely related to bismuth in its analytical properties. We have put forth the opinion that pitchblend perhaps contains a new element, for which we have proposed the name *polonium*[4].

The researches which we are carrying through actually are in agreement with the first results obtained; but, during these researches, we have found a second substance strongly radio-active and entirely different from the first in its chemical properties. In fact, polonium is precipitated from acid solution by hydrogen sulfide; its salts are soluble in acids, and water precipitates them from these solutions; polonium is completely precipitated by ammonia.

The new radio-active substance which we have found has all the chemical properties of fairly pure barium: it is not precipitated by hydrogen sulfide, nor by ammonium sulfide, nor by ammonia; the sulfate is insoluble in water and in acids; the carbonate is insoluble in water; the chloride, very soluble in water, is insoluble in concentrated hydrochloric acid and in alcohol. Finally this substance gives the spectrum of barium, easily recognizable.

We believe nevertheless that this substance, although composed in the greater part of barium, contains besides a new element which communicates radio-activity to it and which, moreover, is a very close relative of barium in its chemical properties.

Here are the reasons which plead in favor of this way of looking at it:

1. Barium and its compounds are not ordinarily radio-active; but, one of us has shown that radio-activity seems to be property of the atom, persisting in all chemical and physical states of matter[5]. From this point of view, the radio-activity of our material would not be due to barium but ought to be attributed to another element.

2. The first substances which we obtained had, in the state of the hydrochloride, a radio-activity 60 times greater than that of metallic uranium (the radio-active intensity being measured by the amount of conductability of the air in our apparatus at the plates). By dissolving the chlorides in water and precipitating a part with alcohol, the part precipitated is much more active than the part remaining in solution. Based on this fact, it is possible to carry out a series of fractionations permitting us to obtain more and more active chlorides. We have thus obtained chlorides having an activity 900 times as great as that of uranium. We have been struck by the scarcity of the substance and, after the course of the operations, we can predict that the activity would have been greatly increased if we had been able to continue. These facts can only be explained by the presence of a radio-active element whose chloride is less soluble in dilute alcohol than that of barium.

3. M. Demarçay has been good enough to examine the spectrum of our substance, with a kindness for which we can never thank him enough. The results of his examination are given in a special note following ours. M Demarçay has found in the spectrum a line which does not seem to be due to any known element. This line, faintly visible with the chloride 60 times as active as uranium, has become notable with the chloride enriched by fractionation up

to activity 900 times uranium. The intensity of this line increases at the same time as the radio-activity, and this is, we think, a very serious reason to attribute it to the radio-active part of our substance.

The different reasons which we have enumerated lead us to believe that the new radio-active substance contains a new element to which we propose to give the name *radium*.

We have determined the atomic weight of our active barium, by determining the chlorine in the anhydrous chloride. We have found numbers which differ very little from those obtained in duplicate with inactive barium chloride; although the values for the active barium are always a little greater, still the difference is of the order of magnitude of experimental error.

The new radio-active substance certainly contains a very great proportion of barium; in spite of that, the radio-activity is considerable. The radio-activity of radium must therefore be enormous.

Uranium, thorium, polonium, radium and their compounds make air a conductor of electricity and act photographically upon sensitized plates. From these two points of view, polonium and radium are considerably more active than uranium and thorium. Good images are obtained on photographic plates with radium and polonium with a half-minute exposure; several hours are necessary to obtain the same result with uranium and thorium.

The rays emitted by the compounds of polonium and radium render barium platinocyanide fluorescent; their action, from this point of view, is analogous to that of Röntgen rays, but considerably weaker. To make the experiment, place upon the active substance a very thin piece of aluminum foil, upon which is spread a thin layer of barium platinocyanide; in the dark the platinocyanide appears feebly luminous in the presence of the active substance.

We realize, therefore, a source of light, to tell the truth very feeble, but one which functions without a source of energy. Here is a contradiction, more or less apparent, with the principle of Carnot.

Uranium and thorium do not give any light under these conditions, their action being probably too feeble[6].

[3] This work was done at the Municipal School of Industrial Physics and Chemistry.
[5] M. P. Curie and Mme. P. Curie, Comptes Rendus, t. CXXVII, p. 175.
[5] Mme. P. Curie, Comptes Rendus, t. CXXVI, p. 1101.
[6] We ask permission to thank here M. Suess, Correspondant of the Institute, Professor at the University of Vienna. Through his good offices, we have obtained from the Austrian government, gratis, a shipment of 100 kg. of residue from the treatment of pitchblend at Joachimsthal, containing no uranium but containing polonium and radium. This gift has facilitated our researches greatly.

Spectral Line of Radium

SUR LE SPECTRE D'UNE SUBSTANCE RADIO-ACTIVE (On the spectrum of a radio-active substance). Note de M. Eug. Demarçay. Translated for CHEMISTRY *by Helen M. Davis.*

M. AND MME. CURIE have asked me to examine, with respect to the spectrum, a substance containing principally some barium chloride and in

which they claim, for reasons set forth elsewhere, the presence of a new element. This substance, dissolved in distilled water slightly acidulated with HCl and submitted to the action of the spark of my coil on a heavy wire, gave a brilliant spectrum which was photographed. For that purpose I made two plates with two different times of exposure, one twice the other. These two plates have given, moreover, according to the intensity of the lines, identically the same result. I have measured them and I am able to see:

1. Barium represented with great intensity by its strong and faint lines;
2. Lead recognizable from its principal lines rather faint besides;
3. Platinum due to the electrodes and the principal lines of calcium due to the solvent;
4. A *notable line* stronger than the weak lines of barium having for λ : 3814.8 (Rowland's scale). It does not seem possible to me that this line can be attributed to any known element: first, because there does not appear on the plates in question any other line than those enumerated above, save some feeble lines from the air, which excludes all the other simple bodies which have only, at most, rather weak lines in the neighborhood of 3814; in the second place, and in addition, because the method of purification employed for the substance excludes precisely the presence of those which might be able to cause them (Fe, Cr, Co, Ni, - - -) and which, moreover, do not show any lines, weak or strong. Neither barium nor lead from elsewhere, as I have assured myself, give any line which coincides with it.

It has been measured by comparison with two lines of platinum 3818.9 and 3801.5 which surround it. It is near and distinct from a bismuth line of moderate intensity.

Conclusion.—The presence of the line 3814.8 confirms the existance, in small quantity, of a new element in the barium chloride of M. and Mme. Curie.

Who's Who in Radium

➤ Marie Sklodowska Curie (1867-1934) and Pierre Curie (1859-1906) discovered radium as a result of the observation by Antoine Henri Becquerel (1852-1908) that radiations affecting a photographic plate are given off spontaneously by uranium ores. These three scientists were awarded the Nobel Prize in Physics in 1903. Mme. Curie was given the Nobel Prize in Chemistry in 1911, the only Nobelist to receive the award a second time. The story of radium and its discoverers is beautifully told by their daughter in "Madame Curie, a Biography by Eve Curie," (Garden City Publishing Co., 1940).

Family tradition is brilliantly maintained by Irene Curie-Joliot who, with her husband, Frederick Joliot, won the Nobel Prize in 1935 for researches on artificially induced radioactivity.

It is interesting to observe in the papers quoted here, the first publications on radium, that the Curies had already realized the theoretical implications of the mysterious new element. Their results contradicted Carnot's law. At first they guessed that their material might be vibrating in tune to unknown waves of energy in space, but by the time the strange element has been concentrated in the barium solution they knew that radium is itself a source of energy.

Refrigeration Important In Chemical Industry

Six Methods of Lowering Temperature

by BARNETT F. DODGE

From a new book, *Chemical Engineering Thermodynamics* (McGraw-Hill $6)

ALTHOUGH refrigeration is usually regarded as the province of the mechanical engineer, there are so many ways in which low temperatures can be usefully applied in the chemical industries that it is important for the chemical engineer to be familiar with the general principles and to know the limitations and advantages of refrigerating processes and equipment in order to make an intelligent decision when confronted with a problem which involves the use of temperatures below that of the surroundings.

A brief and incomplete survey of the applications of refrigeration in the process industries would include such items as liquefaction of chlorine; production of solid CO_2, solvent recovery; gasoline from natural gas; condensation of volatile liquids like CS_2, ethyl ether, and CCl_4; crystallization of salts from solution; dehydration of gases and removal of impurities from them; air conditioning in the manufacture of rayon, photographic film, gelatin, and candy; separation of paraffin wax from petroleum; control of reaction rate in organic reactions such as nitration and diazotization; production of oxygen and nitrogen from air and hydrogen from coke-oven and other gases; and the liquefaction and storage of natural gas.

In a broad sense, refrigeration is the science and art of producing and maintaining temperatures below that of the surrounding atmosphere. Low temperatures can be obtained in various ways, as follows: (1) allowing a phase change to take place in such a way as to extract heat, for example, the evaporation of a liquid such as water or ammonia or the melting of ice or the solution of a salt; (2) expanding a compressed gas or vapor so that it does external work; (3) expanding a gas in the Joule-Thomson way; (4) desorption of a gas; (5) demagnetization of a solid; (6) passage of an electric current through a bimetallic junction (Peltier effect). In fact, any reversible change involving the expenditure of work can be utilized to absorb heat and produce low temperatures. Method 1 is that most commonly used for commercial refrigeration. It is also the basis for the use of the large number of cooling mixtures, of which salt and ice is one of the commonest, that are useful for intermittent cooling on a small scale. Methods 2 and 3 are used for reaching very low temperatures on an industrial scale. Methods 4 and 5 have been used for the production of very low temperatures in the laboratory; 5, in particular, has been applied to the production of extremely low temperatures approaching absolute zero. Method 6 is mentioned merely as a possible method that has never been applied in practice. Any one of these processes can be considered as occurring (1) in an adiabatic system,

in which case the temperature of the system itself will fall; (2) isothermally, with an accompanying influx of heat from the surroundings; or (3) by a combination of both these limiting conditions.

Fire Fighters Could Use Protective Cream

➤ SOLDIERS using bazookas and flamethrowers, as well as tank crews, are protected against flashburns by a new cream issued to them by the Quartermaster Corps. Its prime function is to provide a "fireproof" protection for exposed parts of the body against burns from sudden flashes of flame. As such, it will probably be made available after the war to community fire departments for the protection of its fire fighters.

The cream, which comes in a pocket-size container, does not possess any medical properties and will not cure burns. It was originally developed for the use of Navy gun crews by the Naval Research Medical Institute, and has only recently been adopted by the Army.

"Express elevator to the top floor!"

Concluding the Series on an Introduction to Chemistry

Chemical Analysis

by HELEN M. DAVIS

▶ THE CHEMIST is often asked to find out what a certain substance is, or what it is made of. The first question calls for identification, usually of a compound. Sometimes one simple test—often just a smell—is enough for recognition. To find out what a substance is made of usually requires analysis.

A complete analysis consists of identification of all the elements present and measurement of the quantity of each, in percentages of the total weight of the sample. The report should also show how these elements are combined in the material being investigated.

If the "unknown" is a simple inorganic salt, like sodium chloride, its identification may be very easy, and its complete analysis not a complicated procedure. If you are pretty sure what a certain white powder might be, and equally certain what it is not, simple inspection plus a cautious taste will tell you, for example, whether it is salt, soda, sugar or baking powder. But even in the kitchen it is well to be very careful. Corrosive lye and poisonous sodium fluoride are also white powders.

In the laboratory it is a safe rule *never* to taste anything until you have proved beyond doubt what it is. Chemicals range from inert and harmless through a horrifying variety of poisonous properties to the cyanides[1], only too well described by the classic "boner"—*a drop on a dog's tongue will kill a man.*

Analytical procedures in the laboratory are classified into those for organic and those for inorganic compounds. Compounds of the metals may be identified by a series of tests, based largely on the properties of their sulfides, which form a progressive chain of separations, so that many metals may be identified in the same solution. Running through the succession of tests is an interesting exercise, pleasant enough to offset the smell of hydrogen sulfide, the principal reagent.

[1] It was undoubtedly one of the cyanides which caused the death of Heinrich Himmler. Both sodium and potassium cyanide (NaCN, KCN) are deliquescent white salts, of which a death-dealing dose could easily be packed into a capsule or small vial. HCl in the gastric juice liberates HCN which is speedily taken up by the blood, resulting in death in a matter of seconds. Hydrocyanic acid is also known as Prussic acid.

Qualitative Analysis

The systematic scheme for detecting metals, which forms the basis of the course in qualitative analysis, is based on the properties of metallic sulfides. All metals are classified into six analytical groups, according to their reactions when hydrogen sulfide gas is bubbled into their solutions.

The first group consists of metals nearly all of whose compounds are

soluble. It happens that these are the metals of Group Ia of the Periodic Table, the alkali metals. The second analytical group, likewise, coincides with Group IIa of the Periodic Table, the alkaline earths. They form more insoluble salts than do the metals of Group I, but they do not form insoluble sulfides.

After the first two, the analytical groups diverge more widely from the Periodic Table groups. The third analytical group consists of metals forming insoluble hydroxides. These come down as precipitates instead of the sulfides. Aluminum and the rare earths from Group III of the Periodic Table, fall into this class, but some other elements have this property as well, notably beryllium, chromium, zirconium, titanium and tantalum.

The fourth analytical group comprises metals whose sulfides precipitate from alkaline solution but not from acid. The common metals zinc, manganese, nickel, cobalt and iron are found here, and the rarer ones vanadium, gallium, indium, thallium and uranium.

Sulfides of metals in the fifth analytical group are precipitated from solution whether it is alkaline, neutral or acid. Silver, mercury, lead, bismuth, copper, cadmium, palladium, rhodium, osmium and ruthenium have this property.

The sixth analytical group forms sulfides which precipitate from acid solutions but dissolve when ammonium sulfide is added. Gold, platinum, tin, antimony and arsenic, germanium, iridium, molybdenum, tungsten, selenium and tellurium are in this class.

In carrying through a systematic qualitative analysis, the metals are eliminated by groups, one after the other, from the solution under examination. As each reagent is added the precipitate is filtered off and the filtrate set aside for further investigation. Each precipitate is re-dissolved, if possible, and the resulting solution tested for all the ions which might be present. A great deal of ingenuity has been used in selecting tests characteristic of each element to the exclusion of all others.

The procedure is not only to show that a certain sulfide will precipitate from an acid solution, but to add enough reagent to get all of the ions which will form insoluble sulfides under those conditions out of the solution. Then they will not appear at a later stage of the investigation to mask tests for other ions. The amount of reagent necessary for complete precipitation thus gives a method of measuring the quantity of the unknown compound present.

The analyst proceeds backward through his scheme of separations, removing first the insoluble chlorides. The heavy metals whose strongly colored sulfides are least soluble are precipitated from acid solution with H_2S, and that part of the precipitate soluble in ammonium sulfide is redissolved in that reagent. Groups 6 and 5 have now been removed from the original solution, and a series of special tests allows the metals to be separated and ultimately determined. The original acid filtrate is neutralized with ammonium hydroxide, ammonium sulfide is added, and from the resulting precipitate the metals of groups 4 and 3 may be separated and identified.

The new ammoniacal filtrate holds the metals of groups 2 and 1. From it, ammonium carbonate will throw down barium, strontium and calcium as insoluble carbonates, magnesium and the alkali metals will remain in solution, to be detected by individual tests.

Since acids and ammoniacal compounds are added as reagents in this scheme of analysis, separate portions of the original solution must be used to test for those radicals. Oxides and sulfides are not readily determined by this method of analysis, and such salts as borates, phosphates and especially silicates are apt to interfere with the tests for analytical groups 3 and 4.

This systematic scheme of procedure for qualitative analysis was perfected by Karl Remigius Fresenius, a German analyst, who established a school in 1848 to teach his techniques. His career was crowned by the inclusion of all known elements into one comprehensive series of tests by the time of his death in 1897. The following year saw the beginning of the great outburst of discovery of new elements and new properties that marked the end of the old century and the beginning of the new!

There are other types of tests, beside those on solutions. Mineralogists have clever ways of analyzing a bit of mineral placed on a block of charcoal and heated, with a drop of reagent, in the flame of a blowpipe. A pinch of borax melted on a loop of platinum wire to a transparent bead will fuse a bit of mineral matter, and the presence of certain metals will be shown by the color they give to the borax bead. Sodium, strontium and copper reveal themselves unmistakably by the beautiful colors they lend the colorless Bunsen flame, while potassium, lithium, calcium and barium give more fleeting glimpses of fainter color.

Most definite of all flame tests, the patterns of bright-line spectra, distinct and characteristic for each element, can be made to appear by heating a little of one of its salts in a colorless flame, or by passing an electric discharge through a tube of material in gaseous form. Passing the resulting light through a spectroscope spreads it into a band of distinct wave-lengths. By comparison with the wave-lengths of light from well-known sources, especially the characteristic pure yellow of sodium, the position of lines in the spectrum of an unknown substance can be located. Many new elements were first discovered by their spectra.

Organic Analysis

For testing most organic compounds the analyst determines the various radicals piecemeal. An alcohol will react in one way, a ketone in another. The chemist can tell what a given substance was after he has changed it into something else which he can identify. Melting point, boiling point and crystalline form are the most characteristic properties of organic compounds. Until recently, chemists preferred to work only with such "pure" compounds. Now they are able to handle substances with a wider range of properties, resulting in such materials as plastics and synthetic rubbers.

Fresenius took one step toward systematic analysis of organic compounds, on the order of his inorganic

scheme. He prepared a somewhat similar course of tests for determining the alkaloids, especially those commonly used as poisons. Medical jurisprudence is one of the fields where careful analysts are in demand, as any reader of detective fiction knows. For a delightfully written account of true adventures in the chemistry of crime detection, the reader is referred to "The Poison Trail," by William F. Boos, (Hale, Cushman & Flint, 1939).

Quantitative Analysis

To make exact determinations of the amounts of substances present, the classical method is to weigh the material after carefully drying it until the weight is constant. Metals are weighed as oxides, if possible, as being least subject to change when in that form. Techniques for such quantitative determinations are known as gravimetric methods.

A quicker, more modern technique is volumetric analysis. A definite quantity of reagent is made into a solution of standard strength. It is a normal solution if the weight in grams of reagent per liter of solution is the same as the molecular weight of the reagent. More commonly a 1/10 normal solution is used, with one tenth the amount of reagent per liter.

The reagent prepared in this way is run from a long, thin, graduated tube, called a burette, a drop at a time into the solution whose strength is to be measured. The process is called titration. The reagent is so chosen that an acid will be neutralized by a base, or some equally definite end-point will be reached. Sometimes the end-point is marked by a change in color or appearance in the chemicals under observation. If not, a drop or two of a dye or other substance, known as an indicator, which will change color at the end-point, is put into the solution being measured. The action of the indicator is similar to that of the familiar and convenient litmus paper, although litmus itself is not often used in solution.

When the added reagent causes the indicator to change color, the amount of standard solution which has been used is read from the graduations of the burette. Since the strength of the standard solution is known in terms of molecular weight, the proportion of material in the solution being measured is easily calculated.

Early methods of volumetric analysis called for a sharp end-point, but newer modifications prefer a graduation of color which will give readings by comparison with standard color scales over a small but significant range of concentrations.

Analytical methods of the past century aimed at being all-inclusive. Today's myriad new materials encourage quick, decisive tests for critical qualities only. Every laboratory tends to compile its own test procedures.

The trend of the times is away from over-emphasis on analytical procedures, and toward the methods by which new synthetic compounds are built up.

Analytical Groups of the Elements

➤ In the following list the Analytical Group number follows the name of the element. Symbols mean:

Group 1. Nearly all salts are soluble, element remains in last filtrate. Group 2. Precipitated as carbonates by ammonium carbonate. Group 3. Precipitated as hydroxides by ammonium hydroxide. Group 4. Precipitated as sulfides by ammonium sulfide from alkaline solution. Group 5. Precipitated as sulfides by H_2S from neutral solution. Group 6. Precipitated as sulfides by H_2S from acid solution. A. Determined as an acid. B. Not readily determined in this scheme. C. Rare gas, forms no compounds. ( ) Probable class, method of analysis in this scheme has not been determined.

1 Hydrogen	B	32 Germanium	6	63 Europium	3
2 Helium	C	33 Arsenic	6	64 Gadolinium	3
3 Lithium	1	34 Selenium	6	65 Terbium	3
4 Beryllium	2	35 Bromine	A	66 Dysprosium	3
5 Boron	A	36 Krypton	C	67 Holmium	3
6 Carbon	B	37 Rubidium	1	68 Erbium	3
7 Nitrogen	A	38 Strontium	2	69 Thulium	3
8 Oxygen	B	39 Yttrium	3	70 Ytterbium	3
9 Fluorine	A	40 Zirconium	3	71 Lutecium	3
10 Neon	C	41 Columbium	3	72 Hafnium	3
11 Sodium	1	42 Molybdenum	6	73 Tantalum	3
12 Magnesium	2	43 Masurium	(4)	74 Tungsten	6
13 Aluminum	3	44 Ruthenium	5	75 Rhenium	4
14 Silicon	A	45 Rhodium	5	76 Osmium	5
15 Phosphorus	A	46 Palladium	5	77 Iridium	6
16 Sulfur	A	47 Silver	5	78 Platinum	6
17 Chlorine	A	48 Cadmium	5	79 Gold	6
18 Argon	C	49 Indium	4	80 Mercury	5
19 Potassium	1	50 Tin	6	81 Thallium	4
20 Calcium	2	52 Antimony	6	82 Lead	5
21 Scandium	3	52 Tellurium	6	83 Bismuth	5
22 Titanium	3	53 Iodine	A	84 Polonium	5
23 Vanadium	4	54 Xenon	C	85 Alabamine	(A)
24 Chromium	3	55 Cesium	1	86 Radon	C
25 Manganese	4	56 Barium	2	87 Virginium	(1)
26 Iron	4	57 Lanthanum	3	88 Radium	2
27 Cobalt	4	58 Cerium	3	89 Actinium	3
28 Nickel	4	59 Praseodymium	3	90 Thorium	3
29 Copper	5	60 Neodymium	3	91 Protoactinium	3
30 Zinc	4	61 Illinium	(3)	92 Uranium	4
31 Gallium	4	62 Samarium	3	93 ?	

Mellon Institute Reviews 101 Researches

➤ RESEARCHES on a hundred far-flung fronts, with quicker victory and pleasanter peacetime life as twin goals, are summarized in the annual report of the Mellon Institute, Pittsburgh. The Institute's hundred-fold scientific activity is no mere figure of speech: to be quite exact, 101 research tasks are on the schedule; 94 of them actively pursued during the fiscal year just closed, and seven that have had to be suspended for the duration.

Direct contributions to the war effort, in addition to the researches on shells and rockets, include some exciting new synthetic lubricants, on which some details have to be withheld for security reasons. One of them seems to be a member of the group known as the silicones, that, like oils, are organic compounds containing carbon, but differ in that silicon atoms are substituted for part of the carbon atoms. Other synthetic lubricants are more conventional in their makeup, but are unusual in that they do not become too "thick" in high-altitude cold or too "thin" in tropic heat, so that they can be used in such critical mechanisms as aviation gauges and flyers' wrist watches.

Other new things, useful now for war and even more useful soon in peace, include magnesium alloys, a synthetic "sand" made of ethyl silicate for making molds for fine castings, an unusual plastic material known as vinylnaphthalene, and new kinds of finely pulverized metal for use in powder metallurgy. The latter include manganese, steel and copper powders.

Research items of direct usefulness in the home include textiles with stress on the cost-of-living angle, other textiles with improved water-repellent properties, a new insecticide that may become a competitor for DDT in its deadliness to flies, and strained green soybeans for the baby.

Mountain Leather Asbestos Now Found

➤ MOUNTAIN LEATHER, a type of asbestos that has been only a museum curiosity in the past, is now found adaptable to industrial uses, particularly in filtering, sound-proofing and shock-absorbing materials. A deposit of limited size has been discovered near the entrance to Glacier bay, Alaska, and experiments conducted by the U. S. Bureau of Mines, give promise of possible wide commercial uses.

This native material is known to geologists as paligorskite. When dry it is light in weight, tough, resembles buckskin, and tears somewhat like heavy cardboard. Upon wetting, it absorbs considerable water, swells and becomes soft, can be torn easily, resembles paper pulp, and is slimy to touch. In this condition it can probably be converted to a pulp in conventional paper-mill beaters, and then formed into many lightweight, acid- and fire-proof products.

A special report on mountain leather and its possible uses has been issued by the Bureau.

Research in U. S. A. Speeds Up Alcohol Making from Sawdust

Sugar and Alcohol From Wood

➤ RESEARCH is making it possible to convert wood into high yields of wood sugar and war-vital alcohol in only one-fourth to one-half the time required by a similar German process.

As much as 60 gallons of industrial alcohol can be made from one ton of wood wastes—such as sawdust and chips—by the new methods.

This research developed improvements over the German Scholler process of converting wood by hydrolysis into sugar solutions and then alcohol by treating wood wastes with dilute sulfuric acid under heat and pressure. In 1941 it was estimated Germany had 20 such plants for making alcohol, glycerine, and feed yeasts from wood.

The studies with American woods are described in a symposium on wood sugars in the American Chemical Society's journal, Industrial and Engineering Chemistry. Other papers reported new ways of using agricultural wastes such as corncobs, oat hulls and cottonseed hulls to make industrial sugars, and for producing yeast for animal foods from sugar made from wood.

The United States now faces a serious shortage of carbohydrate crops to meet its food, feed, and industrial needs. In 1939 the United States produced 150,000,000 gallons of industrial alcohol from carbohydrates, but the 1944 production goal was boosted to 600,000,000 gallons. The principal pre-war source of such alcohol was blackstrap molasses, but in 1943 due to import restrictions and shortages, 60 per cent of such alcohol was made from cereal grains, mainly wheat.

Anticipating a possible crisis in manufacture of alcohol, due to lack of carbohydrate raw material, the Chemical Referee Board of the Office of Production Research and Development, War Production Board, two years ago recommended thorough research into production of wood sugar from wood wastes.

As a result, a commercial plant now is under construction at Springfield, Ore., with an estimated capacity of 4,100,000 gallons of alcohol a year from wood wastes, as insurance against future grain shortages.

Studies with American woods which developed improvements over the German Scholler process were carried out by Elwin E. Harris, Edward Beglinger, George J. Hajny, and the late E. C. Sherrard of the U. S. Forest Products Laboratory at Madison, Wis.

The German Scholler process produces 50 to 58 gallons of alcohol per ton of wood, but it takes about 20 hours and other costs of labor and maintenance of equipment are high. American companies investigating it before the war had found it appeared to be uneconomical.

Tests by the Forest Products Laboratory researchers in a pilot plant gave yields of 40 to 60 gallons of alcohol per ton of wood from softwoods, and

33 to 42 gallons from hardwoods, which are lower in fermentable sugars.

Simplifications in the process reduced the time required by the German method, and solved some of the difficulties of plant operation.

"The results of the hydrolysis of spruce, Douglas fir, southern yellow pine, and ponderosa pine indicate that the steaming and resting periods, the low starting temperature, and many other requirements of the Scholler process are unnecessary and actually delay the process of hydrolysis," their report said.

"By revising the methods of hydrolysis it was also possible to obtain solutions containing 6 per cent sugar instead of the 3 to 3.5 per cent obtained in the Scholler process. This permitted a decrease in acid and steam consumption."

The research also developed a process making it possible to ferment wood-sugar liquors in 24 to 30 hours instead of the previous 60 to 96 hours.

Thiophene Obtainable from Petroleum

➤ THIOPHENE CAN now be produced from petroleum by a new process developed by the Socony-Vacuum Oil Company at a cost that will permit its wide use in chemical fields, especially in the plastics, pharmaceutical and dyestuffs industries. This colorless liquid, with chemical action resembling that of benzene, will probably be found valuable in many phases of industries using chemicals when available in sufficient quantities at reasonable prices.

Thiophene resembles benzene in odor as well as in chemical reactions. It is heavier than water and boils at 183 degrees Fahrenheit. It is a chemical compound containing 57.1 per cent carbon, 4.8 per cent hydrogen and 38.1 per cent sulfur. It alters the elasticity, brittleness, hardness and other properties of plastics, the color of dyestuffs, and the physiological effects of medicines.

Under suitable conditions thiophene also reacts with aldehydes, particularly formaldehyde, to form thermosetting resins. In this respect, the behavior of thiophene may be likened to that of phenol in the preparation of thermosetting resins of the phenol-formaldehyde type although there are important differences. It is possible, however, to replace phenol with thiophene in any proportion in the condensation of phenol with aldehydes, under suitable reaction conditions.

Many new and important uses of thiophene are probable. In order that its potentialities may be explored, the Socony-Vacuum Oil Company will provide samples to serious investigators in various chemical fields. The company is now operating a small pilot plant, but has a larger plant under construction that will produce several barrels of thiophene a day.

Answers to Chem Quiz on Page 17

➤ PIGMENTS on the palette are:

Chinese white—ZnO
Cobalt blue—CoO
Chrome green—Cr_2O_3
Chrome yellow—$PbCrO_4$
Vermillion—HgS
Sienna—$Fe_2O_3 \cdot MnO_2$
Ivory black—C

Outstanding Organic Chemist Receives Highest Chemical Honor

Gibbs Medal to Dean Whitmore

▶ Dr. Frank C. Whitmore, Dean of the School of Chemistry and Physics at The Pennsylvania State College, is to be the recipient of the Willard Gibbs Medal at the September meeting of the Chicago Section of the American Chemical Society. The 34th medalist since the award was founded, Dr. Whitmore's name will be added to a distinguished list, including Mme. Curie, isolator of radium, and six other Nobel Prize winners.

The citation stresses Dr. Whitmore's contributions to organic chemistry—he is the author of outstanding texts on *Organic Compounds of Mercury* and *Organic Chemistry*—as well as his research in chemical and petroleum industries and his war activities in connection with aviation fuels, lubricants, synthetic rubber, explosives, penicillin, anti-malarial drugs and airplane camouflage. In addition to this, he has given vigorous support to the policy of "retaining technical men in technical work of value to a technical war."

Born in 1887 in North Attleboro, Mass., Frank Clifford Whitmore graduated at 18 from the Atlantic City High School. Chemistry at Harvard led to graduate work as the last of the many students of Charles Loring Jackson. With him he continued as research assistant after receiving the Ph.D. degree in 1914. Later Dr. Whitmore taught at Williams College and at Rice Institute where, during World War I, he worked on poison gas and

Dr. Frank C. Whitmore

on mercury compounds. From there he went to University of Minnesota, then to Northwestern University as head of the department of Chemistry. In 1929 he became Dean of the School of Chemistry and Physics at The Pennsylvania State College, the position he still occupies.

In connection with his work at Penn State, Dean Whitmore was associated, from 1929 to 1944, with Dr. Pauline Beery Mack and the staff of the Ellen H. Richards Institute in editing the *Chemistry Leaflet*, now appearing as Chemistry. He partici-

pated in its transfer to Science Service when pressure of research duties influenced Dr. Mack to take that step last fall. On account of this connection, CHEMISTRY takes especial pleasure in adding its congratulations to those that individuals, organizations and research journals in the chemical field are offering Dr. Whitmore on this occasion.

The Willard Gibbs Medal is awarded annually by the Chicago Section of the American Chemical Society. It was founded by William A. Converse, named for Willard Gibbs, the American physical chemist, and designed to honor "anyone who, because of his eminent work in, and original contributions to, pure and applied chemistry, is deemed worthy of special recognition."

New Standard Samples of Hydrocarbons

➤ THREE NEW standard samples of hydrocarbons are now available from the National Bureau of Standards, bringing the total number to 46 of these national standards of particular value in rubber, petroleum and chemical industries. They have been prepared and certified for use in calibrating spectrometers and other analytical instruments and apparatus used in the laboratories of these industries.

The first of these standard samples was made available in January, 1944, as a contribution to the war effort. The purity of each is stated on the certificate accompanying it. They are also certified relative to values of refractive index and density, and some for calorimetric heat of combustion. This is for use in establishing heating values of gasoline and other volatile liquid fuels.

Herty Medal to Duke University Chemist

➤ THE HERTY medal was presented May 5 at the Georgia State College for Women by the Georgia State Chemical Society to Dr. Paul Magnus Gross, head of the department of chemistry at Duke University, for his work in physical chemistry and his research in the dipole moments of molecules, sulfa compounds and tobacco.

This medal is a memorial to honor Dr. Charles Holmes Herty, who was born at Milledgeville, Ga., where the presentation was made. During his life Dr. Herty carried out notable chemical research that resulted in the establishment of a great paper-pulp industry in the South. He also promoted the turpentine industry by discovering a process of increasing the flow from southern pines.

World food production as a whole shows a moderate increase since the outbreak of the war in spite of shortages in labor, equipment and fertilizer; a marked decline, however, is found in certain countries most affected by the war.

Alloy Steel Framing for Post-War Houses
Magnesium Furniture, Plastic Paints

New Materials for New Houses

by CLARENCE W. FARRIER

Mr. Farrier is technical director of the National Housing Agency and he told of these impending housing advances in Science Service's "Adventures in Science" broadcast over the Columbia Broadcasting System.

There is a high probability that more steel sections will be used for the framing of a house, thus replacing to a certain extent the use of lumber for this purpose. Alloy steel made in electric furnaces, a wartime development, may be used more extensively. Alloy steel varies from stronger, harder and tougher grades of normal steel to stainless steel with which we are all familiar.

Aluminum has received wide use in building planes and other wartime material, and its price is getting low enough so that it is no longer a luxury metal. Aluminum's relative freedom from corrosion will encourage its entrance into the field formerly given over almost exclusively to galvanized iron and copper for flashing, wire screen, metallic trim and so on. It may even be used for some structural parts.

Magnesium also will undoubtedly have a place in the housing field, particularly for furniture, since it is only 23% as heavy as steel and only twice as heavy as oak. Moreover, it has good strength characteristics and can be fabricated without too much trouble. Furniture made from magnesium, being much thinner, would be much lighter than wood.

We have learned a great deal during the war about plastics, and particularly plastic cements.

A large number of types of glues and cements to meet different conditions of manufacture and service have been developed. This has resulted in increasing the serviceability of plywood in home construction, and our knowledge of building walls of homes on the stressed skin principle used to build aircraft makes it possible to construct sturdy wooden members using far less material—which naturally cuts the cost of the building. Also in the field of plastics, protective paints and coatings will be available after the war, which give promise to be more durable than those we had before the war.

Some of the paints produced in wartime when certain materials were not available have resulted in new formulæ that produced better paints, and these new formulæ will be carried into postwar products.

One of the more important new developments is a protective sheeting consisting of paper impregnated with thermoplastics. When applied to floors it offers the possibility of a non-slip surface of far greater durability and better wearing quality than the wood itself. It can be waxed and made shiny without losing its non-slip characteristics.

LET'S GET THE ADMIRAL HIS HORSE!

Official
U. S. Navy Photo

Admiral Halsey has his eye on a fine white horse called Shirayuki.

Some time ago, at a press conference, he expressed the hope that one day soon he could ride it.

The chap *now* in Shirayuki's saddle is Japan's Emperor—Hirohito.

He is the ruler of as arrogant, treacherous, and vicious a bunch of would-be despots as this earth has ever seen.

Well, it's high time we got the Emperor off his high horse, and gave Admiral Halsey his ride.

The best way for us at home to have a hand in this clean-up is to support the 7th War Loan.

Your personal quota is big—bigger than ever before. So big you may feel you can't afford it.

But we *can* afford it—if American sons, brothers, husbands can cheerfully afford to die.

ALL OUT FOR THE MIGHTY 7th WAR LOAN

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